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A Definition of Science.

"We may confidently hope that the future which the present generation is preparing will be the age of science.

"It might seem redundant to ask the question, 'What is Science?' but we will, nevertheless, answer it briefly. Science is not the monopoly of the naturalist or the scholar, nor is it anything mysterious or esoteric. *Science is the search for truth*, and truth is the adequacy of a description of facts. Science differs from so-called common sense only in this, that its work is done with scrupulous care according to well-considered methods and under the constant supervision of a reexamination.

"Science is based upon observation and experience. It starts with describing the facts of our experience, and complements experience with experiment."
—PAUL CARUS in *Philosophy as a Science*.

The Fear of Knowledge.

In a more or less recent issue of the *Bookman*, Arnold Bennett describes a visit to the library of the average small town about the size of Hilo or Honolulu. He came away with the vivid impression that the average person who reads fiction is bored by fiction, and yet persists in reading fiction only. This average reader carefully avoids the literature of knowledge, because, "Idiotic methods of education have inspired him with a religious fear of knowledge."

"The great truth remains, however," continues Bennett, "that the pursuit of knowledge is, after all, the most fascinating of all pursuits."

"I want to recommend the pursuit of knowledge to the jaded fiction reader. I have, on this occasion, no moral axe to grind. I do not present the pursuit of knowledge as a duty to one's self or to the world. I do not, on this occasion, care twopence about the higher welfare of the jaded fiction reader. I approach him on the plane of pleasure, of diversion. I inform him that he is missing the real fun. I inform him that his fears about knowledge would be unworthy of a puling infant; and if he says to me: 'This is all very well, but how can it be proved?' I reply:

"Very simply. Boldly pursue knowledge for half an hour a day steadily for a fortnight, or—if you have the courage of a lion—for an hour a day for a month, and then see whether fear has given place to a deadly fascination."

A Preliminary Report on the Root-Rot Organism.

By H. L. LYON.

Early in the present year root-rot appeared in a very virulent form in certain fields of Lahaina and H 146 on the plantation of the Oahu Sugar Company. The fields most seriously affected are on new lands irrigated with mountain water; some carry plant cane, and others ratoons. The disease has been most strikingly destructive in H 146 in Field 57. This is plant cane on virgin soil.

While these fields of cane have been succumbing to root-rot on leeward Oahu, a large field of pineapples in Kailua, on windward Oahu, has been almost destroyed by root-rot. These pineapples are also plant crop growing on virgin soil.

At no time during the past ten years has a single case come to our attention where young robust cane has been so quickly and disastrously stricken by root-rot as in the case of this field of H-146. The same is true of the pineapple plants at Kailua. Up to the first of the year this field promised to yield a record-breaking crop. Now it is almost a total wreck. In both cane and pineapples, the disease appeared in spots or streaks across the fields, and from these foci spread with great rapidity.

The problems afforded by the diseases in cane and pineapples were exactly similar, and their investigation has been conducted simultaneously. In our report for January of this year we announced the discovery of a new parasitic organism found in the roots of both cane and pineapples, which were suffering from root-rot. This organism we described as being in the nature of a "protozoan," but said it would probably prove to belong to the *Chytridineae*, a group of lowly parasitic organisms only slightly removed from the true protozoa.

Our further studies have not only shown that this organism does belong to the *Chytridineae*, but have yielded such evidence as to justify the statement at this time that it is the primary cause of root-rot in Lahaina and H 146 in the upper fields of Oahu plantation and in the field of pineapples at Kailua. Further investigations will no doubt demonstrate that this organism is the primary cause of "Lahaina disease" and "pineapple wilt" throughout these Islands, and perhaps in other tropical countries as well.

LIFE-HISTORY OF THE ROOT-ROT ORGANISM.

Before describing the habits and life-cycle of this organism we should say that our account is an interpretation of our observations to date, and it may be necessary to modify it in some details later because of facts as yet undetermined. It has been impossible to observe the organism in transition from one stage to the next throughout its life-cycle, but we have observed it in the stages described and illustrated, and from a knowledge of related organism we probably give a fairly accurate sketch of its life-history.

The most characteristic and stable form assumed by this organism in its life-cycle is the resting-spore. This is shown in Fig. 1. These resting-spores have

been found in great numbers in cane and pineapple roots which were still, to all outward appearances, perfectly sound and healthy, while they have been found in enormous numbers in cane and pineapple roots which have recently succumbed

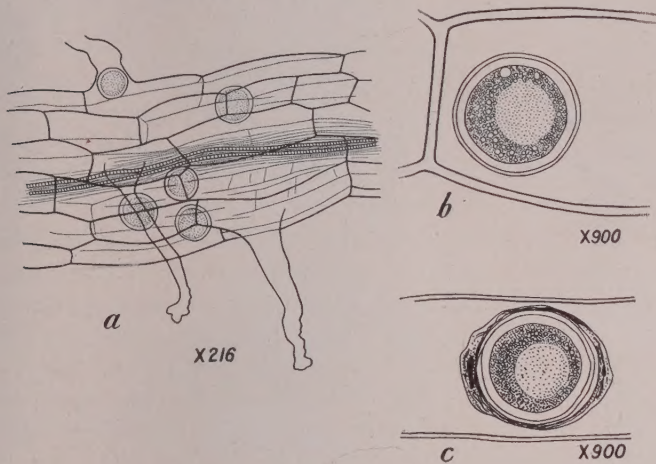


Fig. 1. The Root-rot organism. *a*, Resting-spores in a small cane root. *b*, A resting-spore from a cane root. The wall is composed of two distinct layers. *c*, A resting-spore from a pineapple root. This spore is enclosed in an irregular mantle,—the remnants of a plasmodium or a sporangium.

to root-rot. These spores occur in the soft tissues of the roots, and soon after a root is killed these tissues are completely destroyed by secondary organism, thus making it almost impossible to find any spores of the root-rot organism in old dead roots. These resting-spores were the first evidence discovered of this organism, and as they occurred in living roots absolutely free from other organisms, we concluded that they must belong to some parasite akin to the protozoa, and so reported them.

These resting-spores have a very thick wall composed of two distinct layers. They are well designed to withstand long periods of drying, and undoubtedly serve to carry the organism through dry spells and periods when no roots of a host-plant are available. They are resting-spores in every sense of the word, for we have kept some under observation since January 11, and they are still resting despite the various treatments which we have tried to induce them to germinate.

In living roots containing a few of these resting spores we have also observed plasmodia which we consider the vegetative or feeding stage, and sporangia, which we consider a reproductive stage of this same organism.

The plasmodia are first distinguishable as naked, lobular masses of rather dense protoplasm (living substance) in the root-cells of the host. They usually occur two or more in a cell. Some idea of their appearance may be gained from Fig. 2, a-d, which were drawn from living subjects with the aid of a camera lucida. The sporangia are large thin-walled cells formed within the root-cells of the host. They may be simply oval cells as seen in Fig. 3, c and d, or they may have one or more tube-like protuberances, as shown in Fig. 3, a and b. The protoplasmic contents of these sporangia divide up into a great many separate masses of naked protoplasm, each mass eventually becoming a motile spore. Because these spores have the power of locomotion they are called zoospores. We have observed the escape of these zoospores from a sporangium in a cane root. They first oozed out through a tiny opening in a cell wall onto the surface of a root, where they remained together for a few moments in a motionless

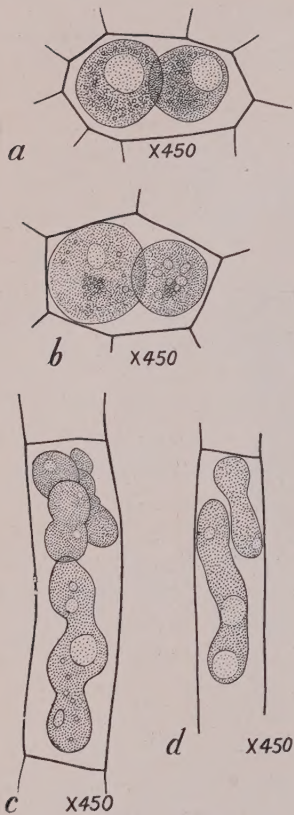


Fig. 2. Plasmodia of the root-rot organism, *a* and *b* from cane roots, *c* and *d* from pineapple roots.

mass, the shape of a raspberry (Fig. 4). Then one after another they would suddenly begin to move, and, pushing out from among their remaining sister spores, quickly swim away.

The life-history of this organism must be about as follows: The free-swimming zoospores bore their way through the cell walls of the root and invade the living substance (protoplasm) contained therein. At first their protoplasm mingles with that of the host and cannot be readily distinguished from it. The substance of the parasite rapidly consumes that of the host, its own bulk increasing in proportion. Having reached maturity, or having consumed all of the protoplasm of the host in its vicinity, the substance of the parasite pulls itself together preparatory to reproduction. The concentration of the protoplasm makes it optically denser, and hence more conspicuous, and it is in this stage that we distinguish it as the irregular plasmodia illustrated in Fig. 2. These mature plasmodia give rise to sporangia or resting-spores. It would appear that a fusion of plasmodia precedes the formation of one or both of these reproductive structures, for the plasmodia almost invariably occur two together in a cell, while the sporangia and resting-spores usually occur singly.

In forming a sporangium the plasmodium first covers itself with a thin wall, and then its protoplasm divides up into a very large number of small masses, each of which eventually becomes a zoospore. These zoospores escape from the sporangium through an opening in its wall and swim about in the soil-water until they find living roots of a proper host into which they bore their way and begin to feed on the protoplasm.

The resting spore is apparently formed within a plasmodium or a sporangium, for a portion of some structure is usually distinguishable as an irregular mantle surrounding the newly-formed resting-spore as shown in Fig. 1, *c*.

We have not seen a resting-spore germinate, but when one does germinate after a longer or shorter period of rest, it undoubtedly gives rise to zoospores exactly similar to those formed in the thin-walled sporangia. See Fig. 5, *b*.

The zoospores are the infant organisms. They enter the host, consume its substance, and grow into plasmodia. These, when mature, pass into a reproductive stage, becoming transformed into either a sporangium, or a resting-spore. The sporangium gives rise to zoospores at once; the resting-spore gives rise to zoospores after a longer or shorter period of rest. The resting-spore serves to carry the organism through periods of drought and famine.

RELATIVES OF THE ROOT-ROT ORGANISM.

The known organisms belonging to the *Chytridineae* are very numerous, but the great majority attack aquatic plants and animals of no economic importance, and hence have received little attention from pathologists. The following species are the more important among those parasitic on economic plants:

Olpidium brassicae attacks young seedlings of the cabbage.

Asterocystis radicis is parasitic in the roots of many plants, including flax, numerous mustards, and several grasses. It is said to cause chlorosis in its host.

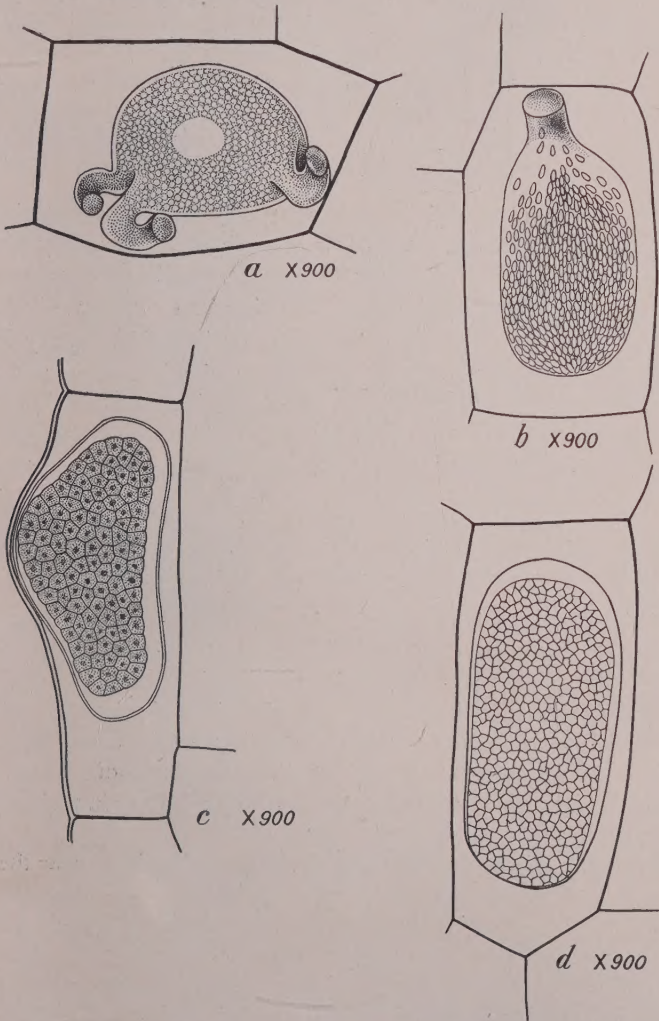


Fig. 3. Sporangia of the root-rot organism from cane roots. The protoplasmic contents of those shown in *c* and *d* were dividing up into small masses, each of which would eventually become a zoospore.

Synchytrium endobioticum is the cause of a serious potato disease known as "wart."

Cladochytrium graminis attacks the roots of many grasses.

Urophlyctis leperoides produces tumors or galls on beet roots.

Urophlyctis alfalfae causes a crown gall of alfalfa.

Urophlyctis trifolii attacks the leaves of several species of clover.

Physoderma zeae-maydis causes a serious disease of the corn plant, attacking the stem and leaves. This disease was first noticed in the United States in 1911 in the State of Illinois. Now, according to Tisdale,*

"the disease occurs throughout this country as far westward as central Texas and Nebraska, and northward to southern Minnesota and New Jersey."

In Fig. 5 we reproduce illustrations of stages in the life-cycles of some typical Chytridiaceous organisms. These help us to understand the nature and habits of the root-rot organisms.

THE ROOT-ROT ORGANISM IN WATER-CULTURES.

No one has ever succeeded in growing a Chytridiaceous organism in artificial culture media. With but a very few possible exceptions, they are all parasitic, and will not develop outside of a living host. We have induced them to grow in the laboratory by the following simple method: Cane sticks from stools seriously affected with root-rot were removed from the soil with a considerable number of old dead roots attached. These sticks were placed upright in jars of water with some eight or ten inches of their lower ends immersed. In a very short time

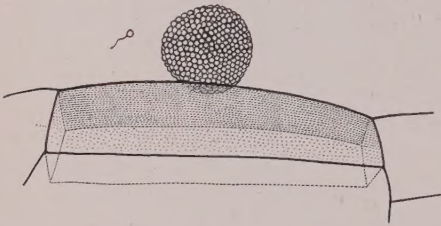


Fig. 4. Zoospores of the root-rot organism escaping from a cane root. They ooze out of the sporangium onto the surface of the root in a spherical mass, then one by one start up and swim away.

each stick developed a copious growth of new roots above the old, dead ones. In the course of a few weeks some of these new roots began to show signs of arrested growth, and a microscopic examination revealed resting-spores, plasmodia and sporangia of the root-rot organism in their tissues. At the same time no mycelial fungi, such as *Fusarium* and *Thielaviopsis*, were in evidence, and the root-hairs were quite intact and uninjured. The plasmodia shown in Fig. 2, a and b, were drawn from cane roots grown in a water-culture in the manner above described.

The root-rot organism seems to favor the new, tender tissue near the tip of the root, and hence it strikes at the most vital point in the root. We have observed large plasmodia and sporangia in the very center of the embryonic tissue which constitutes the growing point of the root. When this tissue is destroyed, the root can grow no further. It may produce lateral roots for some distance back of the growing-point, but if the tips of these are in turn penetrated and destroyed by the root-rot organism, all growth is eventually suppressed. It can be readily

* Journal of Agricultural Research, 16:153.

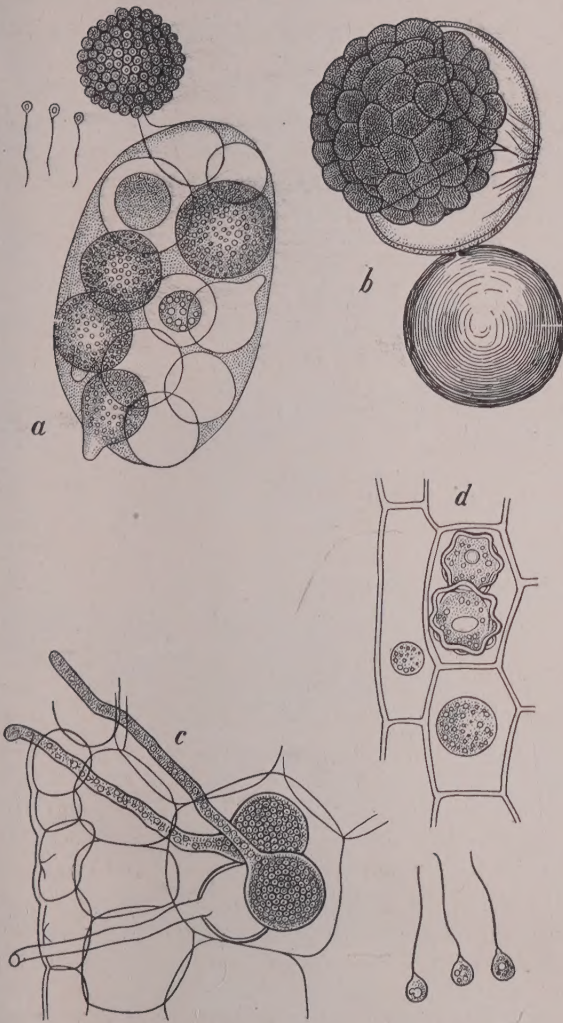


Fig. 5. Some relatives of the root-rot organism. *a* *Olpidium gregarium*, plasmodia and sporangia in a rotifer's egg. *b* *Synchytrium mercurialis* germinating resting-spore. The contents divide up into a large number of zoospores. These zoospores, enclosed in a thin membrane, are pushed out in a mass through a small opening in the hard wall of the resting-spore. The membrane eventually breaks, releasing the zoospores which then swim about in search of a host. *c* and *d* *Olpidium brassicae*, sporangia and resting-spores in cells of cabbage. Three zoospores are also shown. All figures after Nowakowski, and Woronin, in Rabenhorst Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz.

seen how the entire root system of a cane plant can, in this manner, be completely and permanently crippled.

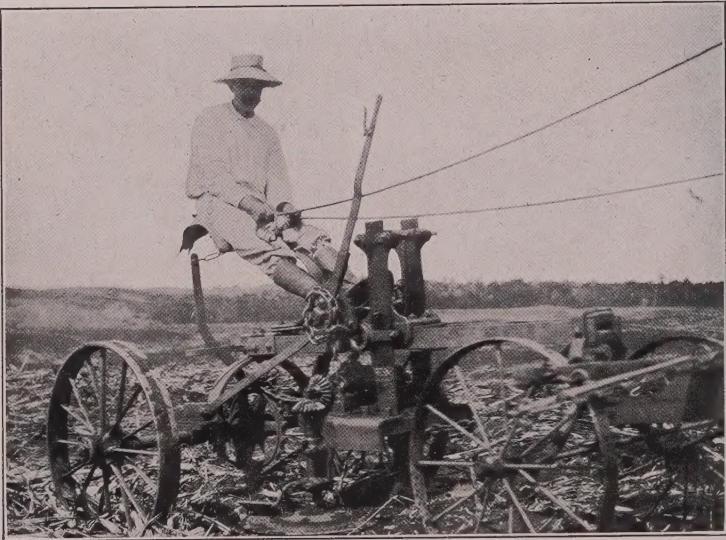
While we have obtained very heavy cross infection from old to new roots of cane in water-cultures, we have secured even more pronounced results with diseased pineapples handled in a similar manner.

A half dozen plants, which were completely wilted, were pulled out of the ground at Kailua and brought over to Honolulu, where they were placed in water-cultures. A few of the lower dead leaves were pulled off, but the dead roots were not removed. The plants were then placed upright in the culture-jars, the lower portion of each stem being immersed. In a remarkably short time each plant produced a new growth of strong roots above the old, dead ones. These new roots were very sturdy, and, for a time, grew rapidly; then of a sudden they stopped growing and shortly afterwards collapsed completely. A microscopic examination of the tissues of these roots showed them to be entirely free from mycelial fungi, but literally filled with the

plasmodia and resting-spores of the root-rot organism. These roots were very thickly covered with long root-hairs which remained turgid and unoccupied by fungi or other foreign bodies, even after the tissues within the root were dead and partially disintegrated.

These results, obtained with diseased canes and pineapples in water-cultures, permit of but one conclusion. The old, dead roots brought from the fields with the diseased plants, contained resting-spores of the root-rot organisms. Some time after the plants were placed in the water these resting-spores germinated, giving rise to zoospores, young, free-swimming organisms, which bored their way into the new roots and eventually destroyed them. These experiments leave no room for doubt as to what is responsible for the root-rot epidemics in the particular fields from which these canes and pineapples were taken.

A New Implement.



Stool shaver in use at Onomea Sugar Co. This implement was designed by Mr. Silver, and it has been used extensively to shave off ratoon cane stubble, giving very satisfactory results.

It differs from the Avery stubble shaver commonly used in Louisiana in that the revolving discs are driven from the rear axle. Also the rear axle is longer and stronger than in the Avery, making the machine better suited to local field conditions.

Sugar Cane Moth Borer in Southeastern United States.

Of particular interest to cane growers in all countries, is Bulletin No. 746 of the U. S. Bureau of Entomology, on the "Sugar Cane Moth Borer,"* a destructive pest of cane in southern Louisiana, Florida and Texas. This comprehensive paper covers the results of several years' intensive study by Federal experts on the work and control of this particular pest. Though the insect under consideration is recorded only from the above localities, closely allied species with habits very similar are found in various parts of South America, the West Indies, Canal Zone, Spain, Mauritius, Ceylon, Java, Borneo, Australia and the Philippines. It is quite remarkable that not one of the twenty-six recorded species of this genus of moths has yet gained a foothold in Hawaii, particularly when its wide distribution is considered, and the fact that it may live on other grasses. This bears ample testimony as to the efficiency of our present quarantine and inspection service.



Sugar-cane Moth-borer. *Diatraea saccharalis*
crambidoides. Grote.

According to the authors of this recent bulletin, twenty per cent of the sugar potentialities of fields where this pest is established in the southern states, is lost. This loss is caused by the larval or worm stage of the moth, which feeds, not to any extent on the leaves, but mostly in the stalk, and into the terminal buds. The stalk thus becomes much channelled and eaten, with frequently little outward evidence of the presence of the pest. This greatly weakens the stalk, causes it to

fall very easily through the action of the wind, and besides stunting the cane and destroying the eyes, a heavy loss in the quality and quantity of the juice results.

The moth is straw-colored, has a wing-spread of about one inch, has a strong flight in comparison with many other insect pests, and can naturally spread very rapidly in a community, once it becomes established. The eggs are deposited on the leaves, and the larvae, upon hatching, immediately begin feeding.

Only one parasite of importance, *Trichogramma minutum*, occurs in Louisiana and Texas, that exerts any appreciable control over this pest. This is a minute egg parasite, and the following paragraph regarding this parasite, quoted from the authors, is of significance:

"The parasites are scarce at the beginning of the season, and in fact eggs destroyed by them were never found earlier than June 18 in Louisiana. As the season progresses they become more and more abundant, until at last they destroy almost every egg cluster of the moth borer."

Other parasites of this genus of moths *Diatraea* are recorded in other coun-

* *Diatraea saccharalis crambidoides* Grote.

tries, and efforts are now under way by the U. S. Bureau of Entomology to study and introduce one or more species from Cuba.

As this borer lives and is distributed easily in shipments of mature cane, which may contain the larvae of the moth, feeding invisibly, or lying dormant as pupae within, the recommendations given for its control in a community are based largely upon the clearing up and burning of all stray sticks in harvested fields, factories, shipping cars, etc., the careful selection by experts in the distribution of seed cane to uninfested regions, fairly deep planting to prevent the moths from reaching the surface of the ground when they begin to emerge from the planted seed, the antiseptic treatment by Bordeaux mixture of all seed cane to new or uninfested areas, and the cutting out of heavily infested or dying young cane in growing fields. The conservation of all leaves, "shucks," or "trash," in order to preserve the parasites which are abundant in the eggs of the moth on such leaves or trash, is also strongly urged. The practice of burning the trash, state the authors, destroys great quantities of parasites which should be conserved as much as possible for attacking the eggs of the moth at the time it begins its activities the following season.

C. E. P.

Ensilage from Cane Tops.*

A small silo was instituted at the Sugar Experiment Station, Bundaberg, Australia, for the purpose of siloing cane tops. These were gathered in the field immediately after the cane had been cut, and were chaffed up, and then trodden well into the underground silage pit. As soon as this was completely filled, it was weighted down with earth. After an interval of three or four months this pit has now been opened, and a trial made of the silage contained therein. The chemist-in-charge of the Experiment Station (Mr. Pringle) states that the station horses took very kindly to it when mixed with other feed, but did not care for it alone; while, on the other hand, cattle took to it at once, and ate it greedily.

As there is an immense amount of cane tops usually going to waste in the cane-cutting season, it is evidently quite possible, in those sugar-growing districts where mixed farming takes place, to silo cane tops and make use of same for feed at a time when forage is scarce. It may, therefore, be recommended to growers having dairy cattle.

[J. A. V.]

* Report of the General Superintendent of the Bureau of Sugar Experiment Stations of Australia.

Results from Experiments in Australia.*

LIMING, CULTIVATION AND MANURIAL EXPERIMENTS.

After cutting the first ratoon crop last year, these plants were carefully ratooned, and while they all came away well, those carrying fertilizer showed a marked difference in color and growth, and drew the attention of all visitors. It was intended to allow these experiments to stand over until 1919; but the disastrous frost necessitated their immediate cutting. From the tabulated results the following deductions are drawn:

The yields from the manured plots, especially the last of the series, are again highly satisfactory. The manure applied was not by any means an expensive one, nor was very much used. The frost, too, did not do so much damage to the manured cane as it did to the unmanured. It will be seen apparently that the lime and subsoiling have had little effect on those plots where they were tried. This bears out the results of the plant and first ratoon crops. In the second series, where lime was used with the fertilizers, the results were not so good as where the fertilizers were used alone in the third series. The latter has given, as it did last year, remarkably good results, showing a difference of 22.67 tons in favor of the manures. Given normal seasons, it is evident that the manuring of ratoons will pay. The great difficulty is the long stretches of dry weather so frequently experienced in Bundaberg. This difference is slightly better than in the first ratoons of last year, which showed an increase of 20.21 tons for manures. This experiment will be continued into the third ratoon stage.

EXPERIMENT WITH BADILA CANE PLANTED IN ROWS HAVING DIFFERENT WIDTHS.

Owing to frost, these interesting experiments had to be harvested, instead of being allowed to stand over till next year and make a crop. This cane requires at least two years in the Bundaberg district. The analytical and crop results, however, as far as they went showed that the cane at 12 months old, planted at a width of 5 feet between the rows gave 2.13 tons commercial cane sugar per acre, as against 1.60 tons for that which had been planted 6 feet apart, and 1.39 tons for the plots where the rows were 7 feet apart. Thus the results shown by both plant and first ratoon crops in this experiment were amply confirmed—namely, that close planting gives the best results. This has been borne out at the Mackay Experiment Station, and in other countries. The high commercial cane sugar is specially noticeable in connection with the second ratoon crop, in view of the frosted state of the cane. The trial will go on for a further crop of third ratoons.

RESULTS FROM PLANTING TOPS, MIDDLES AND BOTTOMS OF CANE RESPECTIVELY.

This experiment dealt with the results of planting tops only, middles only, and middles and bottoms only. The deduction drawn is that top plants give

* The Australasian Sugar Journal, Vol. X, No. 10.

the best results. Experiments formerly conducted in North Queensland tended to show that bottom plants are the next best; and it is intended to carry out some trials at Bundaberg, using different parts of the plant for seed.

HAND AND MACHINE PLANTING.

These plots were planted in March, 1916, for the purpose of determining how much loss took place when cane sets were planted by the machine known as the "cane planter," in place of planting by hand. These experiments were carefully made, and every care was taken, so that the preparation of the two pieces of land was identical, and all other conditions, except the planting, absolutely uniform. Due to the large amount of cane to be cut last year upon the Station, the results did not come to hand for last year's report, so they are now included. It will be impossible to get the yields from the ratoon crops this year in time for this report either.

The analytical results were slightly in favor of the machine-planted cane, in the matter of density of juice, sucrose in juice, purity of juice, and c.c.s. in cane, but the crop results showed a loss of $3\frac{1}{2}$ tons of cane per acre in the case of the machine-planted, and a difference of 0.35 ton in yield of commercial sugar, or slightly over one-third of a ton. Results from the ratoon crop must be awaited before any conclusions are drawn.

ORDINARY CULTIVATION VERSUS NO CULTIVATION.

In order to test the efficacy of continued after-cultivation with the Planet Junior as against no subsequent cultivation, a considerable area of land was given exactly similar cultivation up to planting. As soon as the plants appeared, the cane was divided into two plots, in one of which the horse cultivator was kept moving, whilst the second received nothing more than hand chipping. The difference was only 1.14 tons of cane in the plant crop; but it is thought that the horse cultivation should show up more conclusively in the ratoons. The red soils of Bundaberg, being so light and porous, will probably not exhibit the advantages of subsequent cultivation to the same extent as the alluvial soils of Mackay.

ANALYTICAL RESULTS OF VARIOUS CANES.

Analyses of the following canes were made in September, namely, Badila Seedling, Gingila, Gingor, and Shahjahanpur No. 10. The three former varieties were badly damaged by frost; but the Indian variety was absolutely untouched, and stood out beautifully green, in strong contrast to the frosted canes around it. Though a high fibre cane, it is also of good sugar content, and from its frost-resistance, may prove of great value in low-lying localities. It was the only variety that withstood the frost of July 15th in the field. This cane was sent from the Shahjahanpur Sugar Experiment Station in India, with a letter from the Agricultural Chemist reporting: "We find it a good variety from the Rohilkhand country, where the winter is severe." The Superintendent of our Queensland Sugar Experiment Station adds: "If this cane fulfils its present promise, we shall be pleased to distribute it to growers requiring a cane adapted to frost conditions. The c.c.s. in the Indian cane named was 14.81, as against

14.55 in Badila Seedling, 12.84 in Gingila, and only 6.40 in Gingor. These latter were 24 months old, and Shahjahanpur No. 10 was 27 months old at the time of cutting.

"COMMERCIAL CANE SUGAR."

The following definition, which is embodied in the General Superintendent's report, will be useful for reference:

The expression "Commercial Cane Sugar" is one that has been adopted by the Queensland Cane Prices Board, and is calculated as follows:

$$\text{Total soluble solids in juice} \times \frac{100 - (3 + \text{Fiber})}{100} = \text{total soluble solids in cane}$$

$$\text{Sucrose in juice} \times \frac{100 - (5 + \text{Fiber})}{100} = \text{Sucrose in cane}$$

$$\text{Total soluble solids in cane} - \text{Sucrose in cane} = \text{Impurities in cane}$$

$$\text{Sucrose in cane} \times \frac{\text{Impurities in cane}}{2} = \text{Commercial cane sugar}$$

NEW EXPERIMENTS.

Cane has been planted on land that has been growing lucerne for a number of years, in order to test the theory prevalent in the district that cane will not grow on the red soils after lucerne. An area was prepared and divided into three plots. One was treated with lime and green manure before planting with cane. No. 2 was treated with lime only; and No. 3 received neither lime nor green manure. The cane was planted in August last, so that no results are yet available.

TRACTOR MACHINERY—CANE AND TOPS FOR SILAGE.

Under "Remarks," Mr. Easterby deals with two very important points, concerning which it is to be hoped further information may ere long be available. He says:

"Motor tractors are rapidly coming into use, especially in the Northern cane fields. There are 47 tractors of one make between Proserpine and Cairns. The machine is stated to work on one tin of kerosene per acre, and to plow on the average 3 acres per day. Messrs. Black Bros., of Kalamia, use their tractor for the subsequent cultivation of the cane, and state they can cultivate 22 acres per day of 9 hours at a cost of £2 7s.

A good deal of interest is being taken in siloing cane and cane tops for feed. Excellent silage from chaffed cane and tops have been made at the Kairi State Farm, and cattle devour it with great relish. At Bundaberg a small silo has been put down at the Sugar Experiment Station for testing cane tops for silage purposes.

[J. A. V.]

The Use of Phosphates.

The proper handling of lands, and the fertilization of soils in Hawaii cannot proceed without due recognition of whether or not given areas require additions of phosphoric acid in some form. Though most of the Island soils are well provided with phosphoric acid, and make no response to phosphate fertilizers, it is becoming more and more evident that some lands are dangerously weak in phosphoric acid, to the extent of disastrously affecting what would otherwise be high yields.

Many of the Kauai soils are deficient in phosphoric acid. The same applies to the upper lands on Oahu about Wahiawa and the higher cane lands of the Oahu Sugar Company, and from the experience of Mr. F. G. Krauss at Haiku it is very evident that some of the Maui lands fall in the same category.

In writing to Mr. A. Gartley of C. Brewer & Co. on the subject, Mr. Krauss furnishes a review of his work at Haiku along this line. He says:

"I am just in receipt of your letter of the 7th inst., relative to our use of phosphatic fertilizers, and take much pleasure in giving our experience in their use as fully as possible.

"I might state at the outset that we found our lands here very unproductive for most crops at the very outset of our experience. Even the heavily brushed lands failed to produce more than about 35 bushels of field corn under the best tillage and while the land was still virgin. Jack beans and pigeon peas made a very fair growth, but few other crops gave us adequate returns even when treated with liberal amounts of high-grade fertilizers of such formulas as 5.—8.—9.; the same was true of well-composed manures, and liming sometimes gave detrimental results. I finally undertook a series of fertilizer experiments on a half dozen of our field crops, consisting of corn, potatoes, beans, alfalfa, Uba (Japanese) cane and pineapples. Nitrogen was applied as sodium nitrate, ammonium sulfate, calcium cyanamid and dried blood; potash as sulfate and muriate, and the phosphates as super=, reverted, finely-ground raw rock and bone meal. All these were applied at two rates per acre and both at time of planting as compared with their application after the crop was growing.

"When the above constituents were applied alone, none gave any marked or profitable results, *excepting the super-phosphate and the reverted phosphate*, and their beneficial effects were most marked when applied at time of planting, although in the case of perennial crops such as the alfalfa and Uba cane, additional doses applied after each harvest stimulated further growth. In general, the most profitable amount to apply at time of planting appeared to be 500 pounds per acre in the drill and when the rows were spaced 5 feet apart, as in the case of Uba cane and corn. In the case of beans and potatoes planted in rows 2½ feet apart, each row received a like amount of fertilizer per linear foot, so that 1000 pounds were applied per acre for these latter crops. In the case of alfalfa, 1000 pounds of the phosphate per acre were applied broadcast just before seeding, and twice a year top dressings were made at the rate of 500 pounds for each application.

"In general, it would appear that in a wet season the reverted phosphate is most beneficial, in seasons of scant rainfall the superphosphate appears to have slightly the advantage. However, in our experiments there has been but little

difference in the beneficial effects of these two forms of phosphate, and we are inclined to lean a little towards the reverted form because of its better mechanical condition for spreading and the difference of \$2 to \$4 per ton in favor of its cost.

"The increased yields from the phosphate fertilizers at Haiku have ranged from 80 per cent to over 500 per cent. It is impossible for us to get even a stand of alfalfa on our raw uplands; the seed will germinate and the plants grow not 2 inches in height and then die, but with the phosphatic treatment it has been possible to mature plants 24 inches in height in 30 days and yielding at the rate of 3 tons green matter per acre. Our banner crop of 100 bushels of field corn was the result of heavy green-manuring and a fertilizer rich in phosphates.

"In a comparative test of Maui Red, Calico and Small Navy beans, the highest yield without phosphates was 395 pounds shelled seed per acre; with both super and reverted phosphate applied at the rate of 500 pounds per acre, the highest yield was 2100 pounds shelled seed per acre. In Uba cane, we have had 80 per cent increase in yield, a fifteen-months-old crop yielding 84 tons per acre (total green matter for forage).

"Our regular practice now is to plow under a leguminous crop whenever possible, and then apply phosphates only, just at time of planting the main crop.

"Your suggestion of applying the phosphate to the green manuring crop to get as rank a growth as possible and then getting the value of the phosphates to the cane crop indirectly, is, I think, excellent and certainly worth while including in any project of fertilizer experiments. I have also had the idea in mind and, in fact, have made a single trial. The results were beneficial, but somewhat less so than when we applied the phosphates directly to the main crop."

H. P. A.

Root-Knot.†

In some of the most important cane-growing sections of the state of Florida it has recently been found that much of the cane is seriously infested with root-knot.* This is a well-known disease of many crops, and is caused by a small worm which bores into the roots to feed, stunting and finally killing the plant. Their roots are swollen in places, making soft fleshy galls which give the appearance of a knotted rope, hence the name.

There is no known remedy that could be economically used on cane.

Prevention. Ordinarily the worms are carried from one field to another in dirt clinging to transplanted plants, to the feet of horses or men, or to farm tools. Land that has been in cultivation for several years is more likely to be infested than is new land, particularly if cotton, truck crops or cowpeas have been grown. Dry sandy soils are more likely to be infested than heavy clay or wet muck.

In planting a new field the roots of the seed cane should never be used, for

† Bulletin 14, Univ. of Florida, by A. P. Spencer.

* *Heterodera Radicicola*.



Cane roots injured by root-knot.

if these roots should be infested the root-knot would surely be transplanted to the new field. The canes of even badly infested cane may safely be used for seed provided no dirt is carried with them. In using such cane it would be safer to cut it and carry it out of the infested field and have it bedded on land known to be free of root-knot.

Fields which have become heavily infested with the worms can be at least partially freed by planting them to some immune crop for two or three years. Among such immune or partly immune plants are: Most of the true grasses, including crab-grass, Bermuda, etc.; most of the varieties of corn; rye; oats; velvet beans; and beggar-weed. Iron and Brabham varieties of cowpeas are usually resistant. Peanuts, onions, parsnips, strawberries, and turnips are but slightly affected.

While growing a rotation of crops to free the land of nematodes, weeds that are subject to root-knot should not be allowed to grow. Some species of Amaranth or "careless weed" are especially susceptible. [H. L. L.]

Comparing Different Forms of Nitrogen.

MAKEE SUGAR COMPANY EXPERIMENT NO. 1, 1919 CROP.*

In this experiment a comparison was made of the relative value of the following fertilizers when equal amounts of nitrogen (175 pounds) were applied from each: Nitrate of soda, sulfate of ammonia, and a mixed fertilizer containing nitrogen as nitrate, sulfate and organic in addition to phosphoric acid. The fertilizer was applied in three doses as follows:

Plots	No. of Plots	Pounds of Fertilizer per Acre			Total Pounds of Phos. Acid	Total Pounds of Potash	Total Nitrogen Applied
		Oct. 4, 1917	Jan. 7, 1918	May 1, 1918			
N.	10	322	322	484	0	0	175
H. G.† ...	8	555	555	833	136	0	175
S.	10	244	244	366	0	0	175

In addition to the above, 750 pounds of reverted phosphate and 180 pounds of mill ashes (containing 31.5% K_2O) per acre were applied to the whole area. The phosphate was plowed in, and the ashes spread immediately before planting.

The total amounts of plant food received by the different plots were as follows:

Plots	Pounds per Acre		
	Phos. Acid	Potash	Nitrogen
N.	105	57	175
H. G.	241	57	175
S.	105	57	175

The cane involved in this experiment was Yellow Caledonia, plant cane. The field received thorough preparation, being plowed and harrowed three times before planting.

The results of the harvest follow:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Nitrate Soda	63.14	7.64	8.26
Mixed Fertilizer	64.33	7.95	8.09
Ammonium Sulfate	62.75	7.95	7.89

* Experiment planned by R. S. Thurston and L. D. Larsen.
Fertilized and harvested by R. S. Thurston.

† Mixed fertilizer =

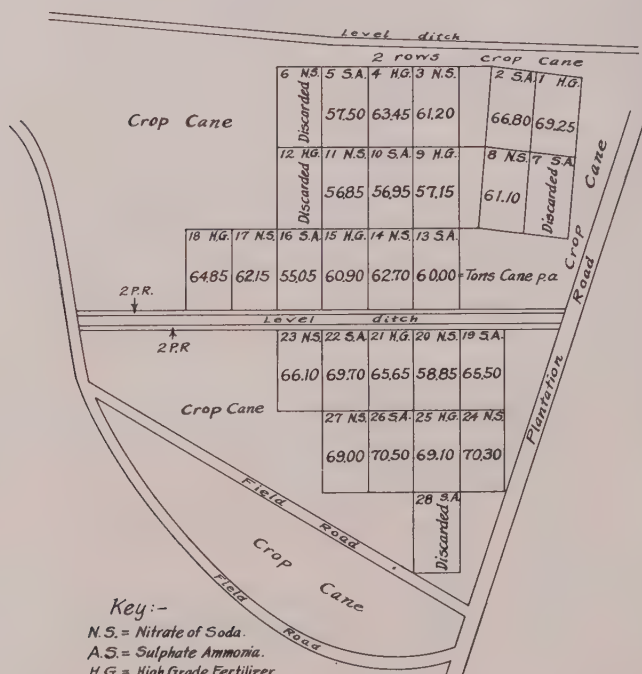
9% N. (4% from sulph. ammo., 4% from nit. soda, 1% organic).
7% P_2O_5 (4% from superphos., 3% from bone meal).

The variations in yield from the different treatments here are rather small, with the largest yield obtained from nitrate of soda and the lowest from ammonium sulfate.

These results are about what should be expected. The 750 pounds of reverted phosphate applied before planting supplied a little over 100 pounds of available phosphoric acid per acre. This was sufficient for the crop. The molasses ash furnished the potash. The question then resolved itself into a question of the best nitrogenous fertilizer. Under normal conditions, the majority of our experiments to date show nitrate of soda to be as good or better than any other form of nitrogen fertilizer. It is also cheaper per unit of nitrogen.

Besides the experiment just reported there were two other experiments in this field, one on amount of fertilizer and the other on time of application. These will be reported in due time. Suffice it to say here that in neither case did we obtain any response to the treatments applied.

MAKEE SUGAR CO. EXP. 1, 1919 Crop
Yields from equal amounts of nitrogen in different forms.



Summary of Results

Treatment	Yield per acre		
	Cane	Q. R.	Sugar
Nitrate of Soda	63.14	7.64	8.26
Mixed fertilizer	64.33	7.95	8.09
Ammonia Sulphate	62.75	7.95	7.89

This lessens the value of the above results, as the field seemed to need little fertilizer of any kind. This may have been due to the thorough preparation which the field received. We plan to repeat this experiment on the ratoon crop to see if similar results will be obtained.

DETAILS OF EXPERIMENT.

Object.

To compare the value of nitrate of soda, sulfate of ammonia, and a mixed fertilizer containing nitrogen as nitrate, sulfate, and organic, in addition to phosphoric acid. Comparison based on equal amounts of nitrogen (175 pounds per acre).

Location.

Field 13, Makee Sugar Co.

Crop.

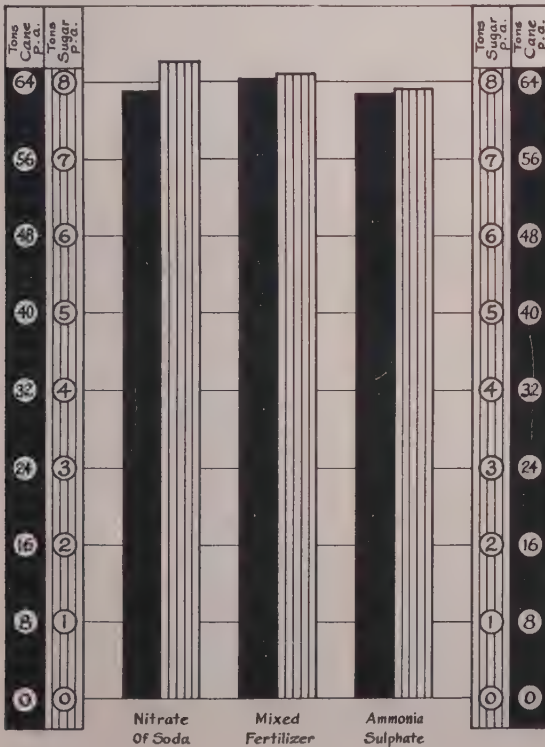
Yellow Caledonia, plant cane.

Layout.

Number of plots = 28. Size of plots = $1/10$ acre, $48.4' \times 90'$, each plot composed of 20 straight rows, $4\frac{1}{2}' \times 48.4'$.

MAKEE SUGAR CO. EXP. 1, 1919 Crop

Yields from equal amounts of nitrogen in different forms.



Plan.

Plots	No. of Plots	Plot Nos.	Fertilizer	Lbs. Nitrogen per Acre			
				Sept. 15, 1917	Dec. 15, 1917	Mar. 15, 1918	Total Lbs. N.
N.	10	3, 6, 8, 11, 14, 17, 20, 23, 24, 27	Nit. Soda	50	50	75	175
H. G.	8	1, 4, 9, 12, 15, 18, 21, 25	Plantation H. G.	50	50	75	175
S.	10	2, 5, 7, 10, 13, 16, 19, 22, 26, 28	Sulfate Ammonia	50	50	75	175

Between second and third plowing reverted phosphate was applied at the rate of 750 pounds per acre. Immediately before planting, mill ashes containing 31.5% K_2O were applied at rate of 180 pounds per acre.

H. G. = 9% nitrogen (3% sulfate, 3% nitrate, 3% organic);

7% P_2O_5 (4% water sol., 3% bone meal).

Nit. soda = 15.5% nitrogen.

Sulf. amm. = 20.5% nitrogen.

The cane was sampled in carload lots at the mill. The juices from plots receiving similar treatment were composited to form one sample.

J. A. V.

Varieties at Honokaa.

HONOKAA SUGAR CO., EXPERIMENT NO. 7 (1919 CROP).*

In this experiment the following varieties are compared: Yellow Caledonia, D 1135, H 109 and Badila.

The test was located in a field at an elevation of about 1000 feet, and the crop was grown under unirrigated conditions. The cane was planted in April, 1917, and considering that it had to contend with the severe drought of that year, the yields are very good.

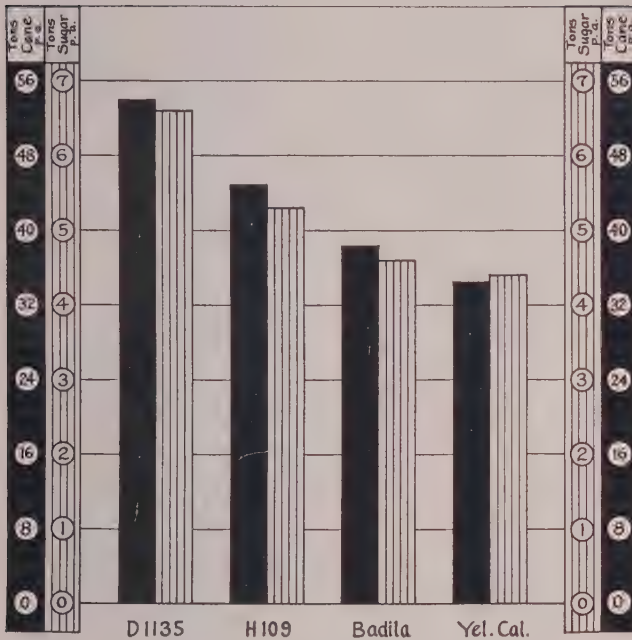
The results place the varieties in the following order: D 1135, H 109, Badila and Yellow Caledonia.

D 1135 led in cane and sugar, with a good margin, giving a yield of 54.1 tons of cane and 6.6 tons of sugar per acre. This was 1.3 tons of sugar more than H 109 averaged.

* Experiment planned and laid out by W. P. Alexander.
Experiment harvested by G. B. Grant.

VARIETY TEST

HONOKAA SUGAR CO EXP. 7, 1919 Crop



AVERAGES BY VARIETY IN ORDER OF SUGAR YIELDS.

Varieties	No. of Plots	Tons Cane per Acre	Quality Ratio	Tons Sugar per Acre
D 1135	12	54.1	8.16	6.6
H 109	9	45.0	8.44	5.3
Badila	2	38.4	8.34	4.6
Yellow Caledonia	10	34.5	7.88	4.4

DETAILED ACCOUNT.

HONOKAA SUGAR CO., EXPERIMENT NO. 7 (1919 CROP).

Object.

To compare Yellow Caledonia, H 109, D 1135 and Badila under conditions prevailing in the unirrigated section of Hamakua.

Location.

Honokaa Sugar Co., Field 18, beginning two lines below the Government road, and on the Honokaa side of the field road.

VARIETY TEST
HONOKAA SUGAR CO. EXP. 7, 1919 Crop
Mauka

		Gov't Road	
FIELD ROAD	1 Y. C.	38.45	30 D1135 54.06
	2 D1135	54.48	31 Badila 39.58
	3 H 109	42.01	32 D1135 55.91
	4 Y. C.	37.58	33 Badila 37.11
	5 D1135	62.20	
	6 H 109	49.86	
	7 Y.C.	36.84	---Tons Cane p.a.
	8 D1135	56.95	
	9 H 109	49.61	
	10 Y.C.	38.26	
	11 D1135	61.25	
	12 H 109	53.34	
	13 Y.C.	36.52	
	14 D1135	61.01	
	15 H 109	49.49	
	16 Y. C.	33.60	
	17 D1135	55.29	
	18 H 109	52.13	
	19 Y. C.	37.16	
	20 D1135	63.45	
	21 H 109	47.46	
	22 Y. C.	37.88	
	23 D1135	56.86	
	24 H 109	39.13	
	25 Y. C.	27.04	
	26 D1135	37.90	
	27 H 109	27.07	
	28 Y. C.	26.73	
	29 D1135	29.86	

SUMMARY OF RESULTS

VARIETIES	YIELD PER ACRE	
	Cane	Sugar
D1135	54.1	8.96
H 109	45.0	8.99
Badila	38.4	9.04
Yellow Caledonia	34.5	8.55
		4.4

Crop.

Plant cane—Yellow Caledonia, H 109, D 1135 and Badila.

Layout.

33 plots, each $1/10$ acre, consisting of six lines, each $4\frac{1}{2}$ feet wide and $161\frac{1}{3}$ feet long.

Plan.

10 plots Yellow Caledonia.

12 plots D 1135.

9 plots H 109.

2 plots Badila.

Fertilization.

Uniform.

POUNDS NITRATE OF SODA PER ACRE.

July 15, 1917	Sept. 15, 1917	Nov. 15, 1917	Feb. 15, 1918	May 15, 1918	Total Lbs. Nitrogen per Acre
300	300	300	300	300	232

Nitrate of soda = 15.5% N.

W. P. A.

Weed Control and Fertilization.

KILAUEA EXPERIMENT NO. 10, 1919 CROP.*

This was a test to determine the effect of weed growth on the growth of cane and to determine the value of fertilizing in the presence of, and in the absence of weeds.

The experimental cane was D 1135 plant, on a non-irrigated field.

The plan of the experiment was as follows:

Plots	No. of Plots	Treatment
D	12	Weeds allowed to grow, fertilizer
E	12	No weeds, fertilizer
F	8	Weeds allowed to grow, no fertilizer
G	8	No weeds, no fertilizer

In the D and F plots weeding was done approximately as in the surrounding field, and at times the weeds were very bad. The E and G plots were kept free from weeds, either by cultivation, hoeing or spraying.

The cane in this field, for some reason, died back to a large extent; on this account the juices were very poor. It took about 15 tons of cane per ton of sugar. The results of the harvest were as follows:

Plots	Treatment	Yield per Acre		
		Cane	Q. R.	Sugar
D	Weeds + Fertilizer.....*	21.31	15.46	1.38
E	No Weeds + Fertilizer.....	29.37	15.69	1.87
F	Weeds + No Fertilizer.....	13.19	14.89	0.89
G	No Weeds + No Fertilizer..	20.38	13.28	1.53

These results are very striking in that they show that the weeds, in this case, completely overcame the beneficial effects of the fertilizer; that is, the plots having no weeds and no fertilizer produced slightly more sugar than did the plots receiving fertilizer without perfect weed control.

Weed control produced as great, if not greater gains than did fertilizing.

The D and E plots received the same amount of fertilizer; in addition to this the E plots had perfect weed control, and produced 8 tons of cane more than the D plots.

Comparing the D and F plots, where weeds were allowed, we find a gain

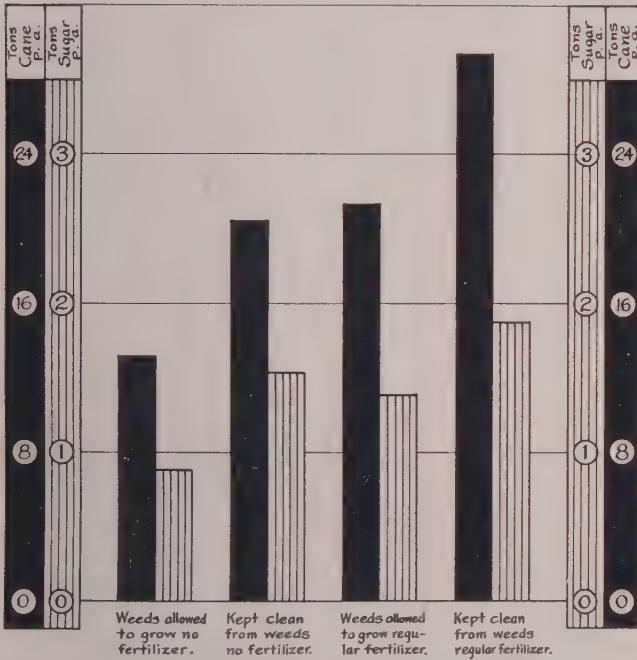
* Experiment planned by L. D. Larsen and R. S. Thurston.
 " carried on and harvested by R. S. Thurston.

of 8 tons of cane due to fertilizing. So we find in this case either weed control or fertilizing produced a gain of eight tons of cane.

Further study shows that these gains are accumulative. Weed control and fertilizer (E plots) produced 16 tons of cane more than no weed control and no fertilizer (F plots).

We believe these results to be very important in showing that we cannot expect to take full advantage of heavy fertilizing unless we also have weed control. But these results would also seem to indicate that in times of acute labor shortage we can partly make up the loss by fertilizing a little more, unless we are already high.

KILAUEA SUGAR PLANTATION CO. Exp. 10, 1919 Crop
Yields from weedy and clean plots with and without fertilizer.



DETAILS OF EXPERIMENT.

Object.

1. To determine the effect of weeds on the growth of sugar cane.
2. To determine the effect of weeds on the response of sugar cane to fertilizer.

Location.

Kilauea Sugar Plantation Co., Field 28.

Crop.

D 1135, plant cane.

Layout.

No. of plots = 40. Size of plots = 1/10 acre, each 12 furrows, 4½' wide by 80.6' long. Each line of plots divided by a 4' road running makai to mauka.

FERTILIZATION IN POUNDS PER ACRE.

Plots	Sept. 1, 1917	Feb. 1, 1918	May 1, 1918
F and G	0	0	0
D and E	300 lbs. N. S.	400 lbs. N. S.	400 lbs. N. S.

KILAUEA SUGAR PLANTATION CO. EXP 10, 1919 Crop
Yields from weedy and clean plots with and without fertilizer.



Summary of Results

Plot	No of Plot	Treatment	Yield per acre		
			Cane	G.R.	Sugar
D	12	Weeds allowed to grow regular fertilizer.	21.31	15.46	1.38
E	12	Kept clean from weeds regular fertilizer.	29.37	15.69	1.87
F	8	Weeds allowed to grow no fertilizer.	13.19	14.89	0.89
G	8	Kept clean from weeds no fertilizer.	20.38	13.28	1.53

NOTE:—In the D and F plots weeding and cultivation is done approximately as in the surrounding field. The weeds are allowed to get a pretty good start on the cane before they are cleaned. In the E and G plots the cane is kept continuously free from weeds either by cultivation, hoeing, or spraying. Cultivation should not be carried on during the rainy weather or when the ground is wet. If weeding is necessary at such times it should be done with hoes.

The cane was sampled in carload lots at the mill and the juices composited for each treatment.

J. A. V.

Mud Press Cake Results at Paauhau.

PAAUHAU EXPERIMENT NO. 13, 1919 CROP.*

This was an experiment comparing the fertilizing value of varying amounts of mud press cake when used in addition to regular fertilization. Except for the mud press the fertilization was uniform to all plots and consisted of 1200 pounds of high-grade fertilizer and 250 pounds of nitrate of soda, a total of 171 pounds of nitrogen and 96 pounds of phosphoric acid per acre. The mud-press cake was applied in the following amounts: No mud press, 1 ton, 5 tons, 10 tons and 15 tons per acre. The mud was applied in the furrow and mixed with the soil by running a subsoiler up and down the furrow before planting.

The results of the harvest are given as follows:

Treatment	Yield per Acre			Gain Over No Mud Press	
	Cane	Q. R.	Sugar	Cane	Sugar
No Mud Press.....	35.7	8.03	4.45
1 ton Mud Press.....	37.2	8.16	4.56	1.5	0.11
5 tons Mud Press.....	39.9	8.22	4.85	4.2	0.40
10 tons Mud Press.....	40.8	8.37	4.88	5.2	0.43
15 tons Mud Press.....	41.6	8.48	4.90	5.9	0.45

These results indicate a gain of 0.4 ton of sugar per acre when applying 5 tons of mud press per acre. This is a rather substantial gain when it is remembered that in addition to the mud press applied, this field received a rather heavy application of commercial fertilizer. Applications of mud press of more than 5 tons did not produce any further increase in yield. All of this cane suffered rather severely in the drought of 1917. This tended to lower the yields and perhaps kept the differences in yield between the different treatments smaller than they would have otherwise been.

The experimental cane in this test was Yellow Caledonia, plant. This experiment will be repeated on the succeeding ratoons, with no further addition of mud press, to determine the residual effect of the different treatments.

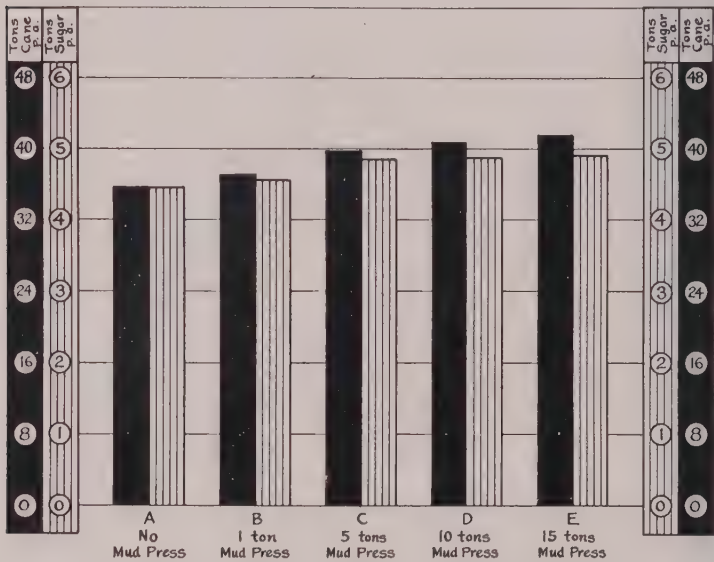
In studying the yields of this experiment by plot it was noticed that two of the plots receiving no mud press gave very high yields compared to the others; these were corner plots. The yields from the "no-mud-press" plots were as follows:

* Experiment planned by L. D. Larsen and W. P. Alexander.
 " laid out by W. P. Alexander and J. S. B. Pratt, Jr.

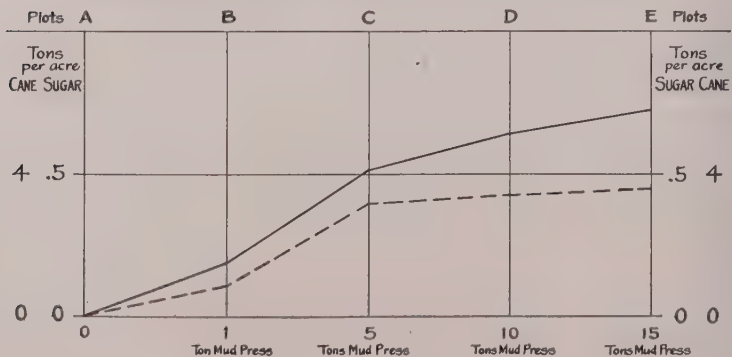
	Cane	Sugar
Plot No. 1.....	45.1	5.43—corner plot
Plot No. 10.....	32.8	4.18
Plot No. 14.....	38.8	4.87
Plot No. 18.....	35.9	4.33
Plot No. 22.....	35.4	4.41
Plot No. 26.....	59.7	7.33—corner plot

The yields from plots Nos. 1 and 26 are seen to be unquestionably abnormal, either due to errors in harvesting, or to abnormal soil or other unknown conditions. For this reason we have discarded these plots.

MUD PRESS EXPERIMENT PAAUHAU SUGAR PLANTATION CO. EXP. 13, 1913 Crop



CURVES SHOWING GAINS FROM VARYING AMOUNTS OF MUD PRESS CAKE.



We believe this to be an excellent example of the importance of making a careful study of the "plot" yields as well as averages before attempting to form conclusions as to the results of an experiment. It also emphasizes the importance of many repetitions.

DETAILS OF EXPERIMENT.

Object.

To test the value of applying varying amounts of mud-press cake (0, 1, 5, 10, 15 tons per acre) in addition to regular fertilization.

Location.

Paaupau Sugar Co., Field 3, mauka of present government road. It lies on the Honokaa side of Experiment No. 18.

Crop.

Yellow Caledonia, plant.

MUD PRESS EXPERIMENT

PAAUHAU SUGAR PLANTATION CO. EXP. 13, 1919 Crop

MAUKA

OLD GOV'T ROAD

HONOKAA →

Cane &
Sugar

1 Discarded	6 37.68 B 4.49	11 47.43 C 5.56	16 49.68 D 5.93	21 45.68 E 5.27	26 Discarded
A 36.93 B 4.55	7 36.80 C 4.48	12 39.68 D 4.67	17 44.68 E 5.36	22 35.43 A 4.41	27 42.05 B 5.11
3 39.50 C 4.93	8 36.18 D 4.31	13 39.25 E 4.63	18 35.93 A 4.33	23 30.43 B 3.79	28 46.93 C 5.64
4 36.80 D 4.41	9 39.75 E 4.69	14 38.80 A 4.87	19 37.68 B 4.73	24 38.43 C 4.81	29 38.30 D 4.64
5 37.75 E 4.47	10 32.75 A 4.18	15 38.55 B 4.69	20 30.18 C 3.66	25 44.43 D 5.32	30 42.18 E 5.00

3' Path &
furrow

Gov't Road

To Honokaa →

SUMMARY OF RESULTS.

PLOTS	No. Of PLOTS	TREATMENT	YIELD PER ACRE		
			Cane	G.R.	Sugar
A	6	No Mud Press	35.73	8.03	4.45
B	6	1 ton Mud Press	37.22	8.16	4.56
C	6	5 tons Mud Press	39.88	8.22	4.85
D	6	10 tons Mud Press	40.84	8.37	4.88
E	6	15 tons Mud Press	41.55	8.48	4.90

Layout.

No. of plots = 30.

Size of plots = 1/10 acre each; 10 lines per plot, each row 5 feet wide and 87.12 feet long; a 3-foot path and furrow separate each plot.

Plan.

	Plots	No. of Plots	Mud Press Tons per Acre
A	6	0
B	6	1
C	6	5
D	6	10
E	6	15

Mud press to be spread in furrow before planting and mixed with soil.

Fertilization—Uniform.

POUNDS PER ACRE

	July 15, 1917	Oct. 15, 1917	Feb. 1, 1918	May 15, 1918	Total Lbs. Nitrogen per Acre
All Plots and Crop Cane..	400 lbs. B 5	400 lbs. B 5	400 lbs. B 5	250 lbs. N.S.	171

B 5 = 11% nitrogen (5% nit. soda, 5% sul. amm., 1% organic);
8% P₂O₅ (5% bone, 3% superphosphate).

N. S. = Nitrate of soda (15.5% N.).

J. A. V.

Hawaiian Seedlings in Australia and Barbados.

In the *Australian Sugar Journal* for January 16, 1919, it is reported by the General Superintendent of Experiment Stations that "the germinations and growth of the new Java varieties have been excellent, but Hawaiian 109 is backward, and does not stand drought well. The other two Hawaiian varieties, viz., H 146 and H 227, are doing better. Q 813 is also doing well."

The following excerpt is from the annual report of Barbados Experiment Station:

"The leading plant variety for the season 1915-1917 was B. H 10, with an average yield of 50.55 tons of cane per acre. Hawaiian 146 was second, with 50.00 tons. * * * Of the first ratoon canes tested, B 6450 was first, with an average acre yield of 33.51 tons, and Hawaiian 146 second, with 33.25."

[W. P. A.]

Making Money from Bagasse.*

The monetary value of bagasse, when burned in furnaces of sugar mills, depends entirely on the locality and on the percentage of dry, combustible matter contained in it at the time of delivery to the boiler-room. It has been figured by government investigators that in isolated cases bagasse may be truthfully and correctly figured at \$3 per ton. In other equally authentic cases the bagasse cannot be worth more than \$1 per ton. This variation is too large to be of any value in determining the average value of bagasse in tropical countries. Each mill will have to make an investigation of its own into the actual monetary value of its own bagasse, and then determine, from the figures obtained, whether or not it would be profitable for this particular mill to purchase another fuel and utilize bagasse in other work.

BAGASSE FOR PAPER MAKING.

For several years past government investigators in the Philippines, in India, Java and Japan, have made experiments with various vegetable fibers which might be found useful in the manufacture of high-grade paper. The supply of materials from which paper has been made in the past, and the enormous increase in the consumption of paper during the past ten years, has brought about a situation in which vegetable fibers can be worked profitably into paper, which a few years ago would have been unprofitable.

The present time is especially auspicious for the starting of a paper mill near large sugar plantations; or, better still, the paper mill can be added to and made an integral part of the sugar mill itself. Machinery for the production of paper is to be had at exceedingly low prices at this moment, because of the dismantling of many special factories which had been built for the manufacture of explosives, and also of many distilleries and breweries. A very large proportion of the machinery required could be obtained in this manner for immediate delivery, while the employment market affords a large selection of competent chemists who could handle the additional work.

The writer has investigated the possibilities of making a paper mill a part of a sugar mill, and he would like to make some suggestions to interested planters in Cuba, who would be inclined to try the project on a cooperative basis.

In the first place, paper can be manufactured all the year around, thereby enabling the factory to hold its employees all the time, and to give them better salaries. Instead of transporting the bagasse directly into the boiler-house, it can be sent directly into the big digesters in which it will later be dissolved, or it can be stacked in huge piles until the grinding season is over and the manufacture of paper can begin as a new and separate operation. Whichever suggestion may

* Dr. Walter Bannard, Sugar, March, 1919.

be adopted, it will be found that the grinding of the cane itself in the mill, and the shredding of the stalks previous to their being subjected to pressure, is the very best possible preparation of the fiber for paper making.

Whenever other vegetable materials are used for the manufacture of paper, the fiber must first be broken up; wood, when used for paper making, must be ground fine, which operation involves an immense amount of power. This great expenditure of power is saved in making paper from bagasse, because the cane is shredded as finely as necessary by the crushers and shredders, in the course of sugar making. The sugar cane is therefore already prepared for paper making, while yielding its sucrose to the mill.

When the bagasse comes from the last roller of the mill it contains still a considerable amount of sucrose, and it also contains a large amount of pith and other soluble solids, which must be eliminated from it. This operation is accomplished in a digester, in which the bagasse is boiled with water, under a steam pressure of about 50 to 60 lbs. The liquid obtained contains all the soluble solids of the cane, and forms, when concentrated and mixed with dry feed, an excellent feed for cattle, swine and mules, while in the unconcentrated form it can be poured out on the fields, thereby providing a high-grade fertilizer for the field.

When the liquid extract is drawn off the bagasse is subjected to boiling with a strong solution of caustic soda, in the same digester. The previous boiling under pressure with plain water has loosened the fiber of the bagasse so greatly that a comparatively small quantity of chemicals is needed to complete the dissolution. All the resins and pith, which are so troublesome in the manufacture of paper from resinous woods, have been eliminated from the mass, and there remains practically nothing but cellulose.

Cellulose, after being freed of its impurities, is bleached by sulphitation—another reason why sugar mills should find it convenient to enter the paper field. The same sulphur towers, the same piping and practically the same general equipment could be used in the preparation of the paper pulp as in the treatment of syrup.

Sugar-mill engineers, who have given thought to this matter, see no reason why some of the big mills should not operate five months or so grinding cane for sugar, and seven months making paper from the bagasse of its own cane and that of some of the surrounding centrals. There is a ready market for all the white paper the sugar mills of Cuba or other West Indian islands could furnish, and with the price of paper as high as \$75 a ton for medium grades, it might prove an excellent investment to take \$1.50 bagasse and turn it into \$75 paper, and buy \$4-a-ton soft coal, or fuel oil to take the place of the low-fuel-value bagasse. A still better opportunity would be to establish a very big paper mill in the cane district to take all the bagasse that can be collected, mix it with all the banana stalks that can be collected in that district, and then produce the high-grade white paper samples of which the government investigators showed at the Panama-Pacific International Exposition. It might prove a highly profitable enterprise for some wide-awake Cuban or American.

[W. R. M.]

Progress Report of Chemical Research Department of the Louisiana Sugar Experiment Station for 1918.*

By F. W. ZERBAN.†

The work of this department has been carried on along three different lines. One investigation dealt with the preparation of vegetable decolorizing carbons, another with the use of these carbons in the sugar factory, and the third with the determination of ash in cane syrups and molasses. Manuscripts on the results of the first two have already been submitted to the Director of the Stations, and of the third to the Referee on Saccharine Products of the Association of Official Agricultural Chemists. As all of these manuscripts will be published *in extenso*, only a summary of them need be presented at this occasion.

1. PREPARATION OF DECOLORIZING CARBONS.

It was recognized about one hundred years ago that the decolorizing power of ordinary wood charcoal, which in itself is very slight, can be increased by "impregnating" the sawdust, or a similar organic material, or charcoal, with certain mineral substance and heating to a high temperature. The impregnating substance must then be removed again by an appropriate solvent, to develop the decolorizing power of the carbon. A great number of patents on such processes, in which different organic materials are impregnated with various substances, have been granted, especially during the last ten years or so. Since the methods used in these patented processes were not directly comparable, it was deemed necessary to find out the various factors which had a bearing on the decolorizing power of the carbon to be made, and particularly to determine the influence of the physical and chemical properties of both the raw material and of the impregnating substance on the decolorizing effect of the resulting carbon. A systematic study was, therefore, undertaken, using various organic raw materials, such as sawdust, cellulose, sugars, starch and organic acids, and a number of impregnating substances, including oxides, acids, bases and salts. We shall not go into the details of this work, but present only the conclusions which we arrived at. It was found that the chemical character of the raw materials employed had only very little effect, if any, on the decolorizing power of the carbon made. However, if organic nitrogenous substances were added to the raw material, the decolorizing effect of the carbon was increased. The mechanical division of both raw material and impregnating substance was shown to have a decided effect. Very finely divided materials, such as starch, and impregnating substances like alumina, or borax, gave better carbons, other conditions being equal, than coarser ones. But the most important point evidently is the state of aggregation of the impregnating substance at the temperature of final carbonization, which was about 900 degrees C.

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Those materials which are either solid or gaseous under these conditions, tend to give good carbons, while those that are liquid yield poor ones. Lime and similar oxides which remain solid have a very favorable effect, as have also certain metallic chlorides, like those of zinc or magnesium, which are gasified at the temperature used. But caustic soda, on the other hand, which is converted into readily fusible sodium carbonate, gives an inferior carbon. As far as the chemical nature of the impregnating substance is concerned, those compounds which attack carbohydrates and similar materials most vigorously, yield effective carbons, provided that they do not give rise to products which are liquid at the temperature of final heating. Other conditions being equal, those compounds having the greatest chemical energy produce the best carbons. Thus anhydrous magnesium chloride, with its very pronounced dehydrating action, yields a much better carbon than zinc chloride, the heat of solution of which is only two-thirds that of the former. Caustic soda would also be expected to give good results, were it not for the fact that the carbonate formed from it melts at the temperature of final carbonization. The proportion between the quantity of raw material and impregnating substance also exerts a marked influence, the decolorizing power of the carbon rising with the proportion of impregnating substance per unit of raw material. The method of carbonization is also important. We have obtained the best results by effecting the carbonization in two distinct stages. The first heating is done in an open vessel, until the mixture is perfectly dry and carbonized as much as possible, but taking care at the same time that the carbon does not ignite. Then the mixture is transferred to a retort which is almost, but not quite air-tight, so that any gases formed may have a chance to escape without any quantity of air entering the retort, which would occasion a loss of carbon. The decolorizing power of the carbon increased with the temperature at which this final heating was carried out. In every case the impregnating substance must finally be removed by treating with an appropriate solvent, which is usually a soluble alkali or an acid. In every case the carbon is finally washed with dilute hydrochloric acid, and lastly with water. It may then be dried if desired. In a few cases, as, for instance, when barium sulfate or difficult soluble oxides are formed in the process, it is practically impossible to remove all of the impregnating material, and the consequence is that the carbon is high in ash and of lower decolorizing power than it would be if it could be made practically ashless.

Having thus ascertained the different factors which have an influence on the decolorizing power of the carbon, we could now make a search for such materials found in nature or obtained as by-products in certain manufacturing processes, which already contain both the organic raw material required and also an effective impregnating substance. Considering first the by-products of the cane sugar industry, we have bagasse, filter-press mud and molasses. The bagasse yields a very poor carbon, because the ash in bagasse is very low, even though it consist largely of silica. It could, however, be impregnated with lime, for instance, and a good carbon made from it. The filter press cake is a good material for making carbon, because it is high in lime salts. After the stuff is retorted, simple boiling with hydrochloric acid furnishes a very effective carbon. Boiling out with caustic soda, previous to the acid treatment, would give a still better carbon, because it will remove considerable quantities of silica from the ash. The molasses in itself

gives a poor carbon, owing to its low content of ash, which, moreover, is readily fusible. But impregnation with concentrated sulphuric acid, which carbonizes the material at the same time, gives a cheap and moderately efficient carbon. (Lyon and Peck, United States Patent No. 1251546.) Lime may also be used as an impregnating substance, and in this case a very good carbon is obtained. (Weinrich, private communication.)

The rice hull carbon is so well known to you, that it is hardly necessary to discuss it at length. Its method of preparation and the results obtained with it at the Station sugar house have already been published in part, and more on this subject will appear in print very shortly. For this reason we only mention that priority on the process of its manufacture has been awarded to Mr. W. G. Taggart, Assistant Director of the Station, and that the patent, when issued, will be dedicated to the public. This should greatly stimulate factory experiments on the part of our planters.

We have also found that certain aquatic plants, and particularly the giant kelps of the Pacific Coast, which are now being utilized for the extraction of potash, give very superior carbons. The process of manufacturing a decolorizing carbon from kelp has been patented by the writer (United States Patent No. 1290002). This patent has likewise been dedicated to the public.

Another very efficient carbon has been developed by the Station, but this is of greater interest to one of our insular possessions than to this State. There is found in certain parts of Porto Rico a black vegetable soil, which consists almost entirely of organic matter. The subsoil underlying this vegetable mould is a carbonate of lime of high purity and in a fine state of division. By mixing the dried topsoil and the dried subsoil in proper proportions, and applying our process of carbonization, a very effective carbon can be secured.

A number of other plants and by-products were tried, with varying success, but none of these appear to be destined to become of practical importance.

The results obtained so far in this investigation only show in what way highly efficient decolorizing carbons may be made, but do not give us a clue to answer the fundamental question concerning the cause and nature of decolorization itself. It is evident that all of the work done only serves as a basis for this further research, which is now in active progress.

2. THE COLOR OF SUGAR CANE PRODUCTS AND THE USE OF DECOLORIZING CARBONS IN WHITE SUGAR MANUFACTURE.

Our recent sugar-house tests were undertaken with the object of clearing up some questions which had been left partly or wholly unanswered in the previous experiments. During the campaign of 1917-18 we were unable to carry out quantitative color determinations in the various products, for the lack of proper laboratory equipment. For the same reason we were unable to seek an answer to the question, opened up by Schneller's investigations, as to how the iron and the polyphenols found in our cane products affect the color of the same. The solution of this problem was practically reached during the summer, and the grinding season saw us prepared for the work contemplated.

We also wished to gain some further information on the effect of decolorizing

carbons on the quality of the various products and the yield of first sugar. The work of 1917 had been done on a very small scale, one clarifier (3000 pounds) each of juice being used for the tests with and without carbon, respectively. This had a great advantage from the analytical standpoint, because the two juices which were to be compared were first thoroughly mixed before treating one of them with carbon, and we thus had an absolute basis for comparing their composition by analysis. But, on the other hand, the amount of juice used in each case was too small to give us any satisfactory data on comparative sugar yields obtained, since the boiling to grain had to be done in a very small pan, which did not enable us to make the different sugars under comparable conditions. For these reasons we decided to make further tests on our regular sugar-house scale, which means the use of at least five clarifiers full of juice to each strike. This furnished us a better basis for determining the relative quantity and quality that may be expected in actual factory operations on the large scale, but had the drawback that the juice used in one run did not have the same composition as that used in the others. It will, therefore, be necessary, in interpreting the actual results obtained, to make allowance for differences in the quality of the juices used in each run.

Prinsen Geerligs points out that in the manufacture of plantation white sugar too much attention should not be paid to the increase in purity effected by a certain method of clarification, and that it is much more important to improve physical properties by the removal of color and of colloidal impurities, the quantity of which is not sufficient to affect the purity to any great extent. If this is so—and there seems to be no reason to doubt it—then any process which promises to fulfill these two conditions, deserves the attention of the sugar manufacturer. This was our reason for investigating the color of all the different products obtained in the sugar-house by the sulfitation white sugar process, including a modification of it, and of those made by using vegetable decolorizing carbon in addition to the usual clarifying agents. At the same time we also carried out a study of the nature and relative quantity of what appeared to us a very important constituent of the coloring matter existing in the products.

The nature and relative importance of the well-known coloring matters occurring in the cane and formed during the manufacturing process are discussed in detail in the standard handbooks on white sugar manufacture from cane, by Prinsen Geerligs, and by Harloff and Schmidt, and a short summary of what they have to say on the subject will suffice here. Considering the coloring matters of the cane itself, the

Chlorophyll is not of much practical importance, because it does not dissolve in the cane juice, but occurs in it only as a mechanical impurity which is readily removed with the scums.

Anthocyanin is to be considered more seriously. Anthocyanin is a collective name for the compounds which impart varying shades of red, purple, or brown to the rind of certain cane varieties. They are soluble in cane juice, are precipitated by large amounts of lime, but only incompletely by small quantities. It appears that the elimination by lime is not due to a chemical process, but is a case of physical absorption. Sulphurous acid decolorizes anthocyanin to some extent, but only temporarily. In the carbonation process anthocyanin is completely removed,

while in the sulfitation process the proportion eliminated will depend on the quantity of the precipitate formed in the clarification.

Saccharetin, the "incrustating" coloring matter of the cane, is insoluble in cane juice, but, very much like chlorophyll, enters the raw juice mechanically along with fine particles of fiber. As long as the reaction of the juice remains acid, it does not dissolve, but whenever the fiber particles come in contact with lime or another alkali, the saccharetin is dissolved with a yellow color. But even this is not very dark, and the saccharetin as such is, therefore, not considered of very great importance, especially in acid processes, as are generally used in Louisiana. We shall see, however, that under certain conditions the saccharetin may contribute materially to the coloring matter of the products.

The three coloring matters mentioned are the only ones present in the cane itself that were, some years ago, considered of any importance.

Turning now to the coloring matters formed during the process of manufacture, we shall first consider those produced by the

Effect of high temperatures. Solutions of all three sugars existing in cane juice darken perceptibly when heated to high temperatures for any length of time. Levulose does this most readily, dextrose less so, and sucrose least. In the presence of other impurities always found in cane products, like neutral salts and nitrogenous bodies, the darkening is more pronounced. The exact nature of the decomposition products is not known, but they usually do not contain true caramel, this latter substance being only rarely formed in factories with modern equipment, and then only under abnormal conditions. They can be reduced in quantity by proper syrup treatment, but any formed in the pan cannot be eliminated as such by any method known. In slightly acid solutions they do not form as readily as in neutral solutions.

When the reaction of the products becomes alkaline, however, then we encounter one of the worst enemies of white sugar manufacture, the *Glucosates* of alkalies and alkaline earths. When a solution containing reducing sugars is heated with lime or a similar alkaline substance, it soon begins to darken and finally becomes dark brown, and even almost black. The reducing sugars are decomposed and converted into acids, known as glucinic and saccharinic acids, which combine with the lime present, and reduce the alkalinity of the solution. Even salts of strong bases with weak acids, like organic lime salts, have the same effect as the bases themselves, even though to a smaller extent. Their formation can be entirely avoided by keeping the reaction of the products constantly on the acid side.

The authors already quoted also mention an outside source which may give rise to a dark color in the products, namely,

Iron salts, taken up by the products from the machinery through which they have to pass. Iron has long been known as the source of the dark color of certain beet sugars. Prinsen Geerligs showed that the greyish tint of some cane sugars is likewise caused by iron, and, what is more important, that the iron compound was found to be present not only in the molasses adhering to the sugar, but in the crystal itself. He suggested that the iron was in the form of a saccharate. In Louisiana, Shilstone, and also Morse, called attention to the fact that iron was responsible for the dark color of certain sugars. The former expressed the opinion

that, on account of the very small quantities of iron present, the iron compounds themselves must be of an extremely dark color, and suggested iron salts of "organic acids." From further investigations in Java the conclusion was drawn that, as only ferric salts give any trouble, and, furthermore, iron does not crystallize with sucrose in an acid medium, any deleterious effect of iron could be entirely prevented by the use of acids, especially such as sulfurous acid, which latter would not only reduce the iron to the ferrous state, but also provide the necessary acidity to keep the iron from entering the sugar crystals.

Later, Langguth-Steuerwald, in his researches on saccharetin, found that this compound as prepared by him gave a dark coloration with ferric salts, and upon dry distillation yielded pyrogallol. He concluded that saccharetin and its decomposition products were, in conjunction with iron, responsible for the dark color of sugar products.

Taking up this subject in Louisiana, Schneller called attention to the fact that, while saccharetin or products derived from it, could in combination with iron cause a dark color, there exists in cane a constituent which affords a much simpler explanation, because it is soluble in water and in cane juice. Furthermore, this substance must have formed part of the saccharetin of Langguth-Steuerwald, owing to the method of preparation employed by him, and must, therefore, be at least partly responsible for the iron reaction of this substance. We refer to "tannin," first discovered in cane by Szymanski, precisely through its reaction with iron salts, giving rise to a dark green color or precipitate. These results were confirmed by Browne, and Schneller was the first to point out that the presence of tannin or similar water-soluble polyphenols could easily explain the dark color of cane products. Schneller also called attention to the fact that the presence of aromatic compounds like saccharetin was not confined to the sugar cane, but that they are found in all lignified plant tissues. This subject requires further study, but the fact remains that for the present the tannin of the cane must be considered the most important constituent of cane giving the iron reaction. Schneller suggested that the polyphenol of the cane need not necessarily be a true tannin, but may be of much simpler constitution, as, for instance, represented by pyrocatechin, which also gives the green iron reaction. Investigations on the nature of the cane tannin are now in progress.

The polyphenols of the cane assume even greater significance, from the standpoint of the color of raw juices, as has already been pointed out by one of the authors of this article. The muddy green color of these juices has usually been ascribed to the presence of finely divided fiber particles carrying chlorophyll. But the color of the mill juice itself, after the removal of suspended matter, is usually green, and this is simply due to the compounds formed from the polyphenols and the iron dissolved from the mill by the cane juice. This iron is at the beginning in the ferrous state, but a rapid change takes place, owing to the simultaneous presence in the juice of oxidizing enzymes. These were first discovered in cane by Raciborski, whose results were confirmed by Browne. The renewed study of this subject at this Station has brought out the fact that cane juice contains an oxidase (a laccase), peroxidase, and tyrosinase. These, in connection with the polyphenols and iron, explain all the different colors that a raw cane juice may assume. It was found experimentally that raw juice—which in the sound cane

itself is devoid of color—if extracted in the absence of iron, does not turn green, upon exposure to air, but dark brown. This color is due to the oxidation taking place under the influence of the enzymes named on the polyphenols of the cane. The tyrosinase does not act on the polyphenols proper, but on the tyrosin which was found by Zerban to be present in the cane juice in very small quantities. This latter reaction plays a very small part, however, in comparison with the effect of the oxidase on the polyphenols. The exact color of a raw juice will depend on the relative quantities of polyphenols and iron. If no iron is present, the color will be brown, but will be more and more greenish with increasing quantities of iron extracted from the mill.

It should be mentioned here that anthocyanin also belongs to the polyphenols, and that the color of its solution is darkened by iron salts.

It has further been found that pyrocatechin may be formed by the overheating of sucrose solutions, and also of dextrose solutions.

With the knowledge which has thus been gained of the role played by both polyphenols and iron in the color of sugar-cane products, we can now summarize what importance may be attached to the different coloring matters, based upon their effect upon the color of the various products made in the processes generally used in white sugar manufacture in Louisiana.

The chlorophyll is of no practical importance, as has already been pointed out. Since the liquors are always kept acid, and can become alkaline only locally, owing to the action of lime particles—and even this only temporarily—the effect of glucosates can also be largely discounted. For the same reason the saccharetin itself cannot be of much importance, but can become so by giving rise to compounds which give the iron reaction. This leaves, then,

(1) The effect of that part of the anthocyanin from dark-colored canes, which has not been precipitated. This is evidently of some importance by itself and more so owing to its reaction with iron salts.

(2) The effect of the products formed by the action of high temperatures on the sugars in the presence of other impurities. But this effect is much less in slightly acid solutions than in neutral or slightly alkaline media.

(3) The effect of the polyphenols, principally in connection with iron. It is maintained in Java that iron salts are of no great consequence because they can be rendered innocuous by the use of sulfurous and even any other acid. But this is only conditionally correct, because we have found that our products, in spite of being heavily sulfured, do contain a large part of the iron in the ferric form, and also because, if there is any trace of molasses film left on the sugar crystals, the ferrous iron present will be gradually oxidized to the ferric form, and may thus cause a subsequent darkening of the sugar. The effect of other acids is also problematical, because according to Schneller's results the light color produced in sugar products by adding acid is largely due to a dissociation of the iron-polyphenol compounds; as soon as the acidity is lowered, or even the temperature lowered, recombination immediately takes place.

Since the question of the effect of polyphenols and iron on the color of the products appeared to be of such great importance, we devoted the last grinding season principally to a study of the color, and of the iron and polyphenol content

of our products, as made by the usual methods of clarification, and by the same processes with the additional use of a decolorizing carbon.

The quantity of cane at our disposal permitted us to make five full runs, and a small sixth run. The first of these cannot be compared directly with the others, because the products of the initial run in any sugar house pick up so much foreign material from the unused machinery, tanks and pipes as to become entirely abnormal in many respects. Runs 2 to 5 were used for experiments with carbon on juice, and run 6 for one on syrup. The detailed plan was as follows:

Run 1 (straight sulfitation with high final acidity; without carbon), consisting of five clarifiers. The raw juice was sulfured to an average acidity of 6.1 cc. n/10 per 10 cc. of juice, limed back to an average acidity of 1.6 cc., heated to a break, and then treated as usual, running the clear juice into settling tanks, and filtering bottoms and scums through a press.

Run 2 (straight sulfitation with high final acidity; with carbon), consisting of five clarifiers. The raw juice was sulfured to an average acidity of 5.6 cc., and limed back to one of 1.6 cc. Then rice hull carbon was added at the rate of 1 per cent on the weight of the juice mixed well with the juice, the liquor brought to the boiling point and filtered in its entirety through a press.

Run 3 (straight sulfitation with high final acidity; without carbon), consisting of five clarifiers. Raw juice was sulfured to an average acidity of 6.2 cc., and limed back to 1.6 cc. The further treatment was the same as in Run 1, no carbon being used.

Run 4 (sulfitation-phosphatation with high final acidity; without carbon), consisting of five clarifiers. Raw juice sulfured to 5.66 cc., and limed back to as close to neutrality as possible. Then the juice was again acidified with phosphoric acid (U. S. P. grade of 85 per cent) to an acidity of 1.1 cc. It was then clarified like in Runs 1 and 3, no carbon being added.

Run 5 (sulfitation-phosphatation with high final acidity; with carbon), consisting of five clarifiers. Raw juice sulfured to 5.4 cc. and limed back to as close to neutrality as possible. Then 0.7 per cent rice hull carbon on the weight of the juice was added, the juice being acidified at the same time with phosphoric acid to 1.3 cc. The juice was well mixed, brought to a boil, and all of it filtered through the press.

Run 6 (straight sulfitation with low final acidity; carbon used on syrup), consisting of three and a half clarifiers. Raw juice sulfured to 5.0 cc., and limed back to 0.2 cc. Heated to break, and then treated in usual manner. The clarified juice was boiled to syrup. Part of this syrup was treated with 5½ per cent of its weight of rice-hull carbon, then the acidity raised 1 cc. by addition of phosphoric acid, the mixture boiled and passed through the press. This experiment was not carried further than the syrup, because its quantity was insufficient for making a full strike. The treated syrup was again mixed with the untreated, all of it boiled to grain, and the strike was finished by drawing in first molasses from the other runs. The sugar and molasses from this run are, therefore, not included in the experiment.

It will be noted that in Runs 1, 2 and 3 the generally accepted sulfitation process for making white sugar in Louisiana was adopted, carbon being used in Run 2, and left out in Runs 1 and 3. In Runs 4 and 5 the juice, after being

sulfured and limed back to neutrality, was acidified to decided litmus acidity which, according to Cross' work at the Station, does not cause inversion, and according to the inventors of Norit, materially assists the effect of the carbon. Carbon was left out in Run 4, and added in Run 5.

All of the products made in these tests, raw juices, clarified juices, syrups, first sugars, and first molasses, were analyzed by the methods in common use, and in addition to this we also made determinations of the relative quantities of total coloring matter, and of the percentages of ferrous iron, ferric iron, polyphenols, and ferric polyphenol compounds. In carrying out these special analyses we found it necessary in all cases where carbon was not used in the clarification, to heat the liquids with a little kieselguhr and filter through filter paper, in order to remove finely-suspended matter. This was needed especially in the case of raw juices. It must, therefore, be kept in mind that wherever the color of "raw" or "mill" juice is spoken of, we mean the liquid obtained after treating with kieselguhr. This latter substance in itself has a very slight decolorizing effect which is not sufficient, however, to affect the results.

While the figures found for the non-sugars mentioned above permitted us to make some very interesting observations, a direct comparison of the products of each run with the corresponding ones of the other runs was not possible, because, although the juices were all of approximately the same density, the other products were so only in some cases, and then wholly by accident. In order to have a more secure basis on which such a comparison could be made, we calculated all the figures on the basis of total non-sugars in each product. (Total solids less sum of sucrose and reducing sugars.) The calculations could not be based on the total solids, because sucrose is removed when the first molasses is obtained. It is true that the total non-sugars also change somewhat in quantity, by clarification, scale formation, decomposition by high temperatures, and any increase or decrease in constituents is partly due to a decrease or increase of the non-sugars. But these nevertheless affording the only basis on which such calculations can be based, and they should be fairly reliable for this purpose.

Total color. The total color in the six raw juices did not vary a great deal, owing to the fact that in each run mixed varieties of greatly varying color were used.

Mixed juice samples taken daily showed somewhat greater variations. The effect of the anthocyanin in purple canes, as influenced by the pressure of the mills, was strikingly shown by some tests in which we compared juices from green cane and purple cane in samples taken from the different sets of rollers in the mill. These samples were collected directly from under the rollers of the first and third sets, and, therefore, had only minimum quantities of iron. A sample of mixed juice was also taken at the point of issue from the mill. There was only a very slight difference in the color of the first mill juice from green and purple cane, both showing about 10 units, the latter being a shade darker. But the third set of rollers, with its greater pressure, gave a juice with 27 color units from purple cane, and of only 21 from green cane. The mixed juice from the purple cane showed 18.5 color units, and the green only 13.

The darkest average raw juice was obtained in Run 2, for reasons which will become apparent in our further discussion.

Turning now to the color of the clarified juices, we noted the remarkable fact that in all the runs made without carbon the color of the clarified juice was darker than that of the—boiled and filtered—mill juice from which it was made. In Runs 1 and 3 the increase in color was quite considerable, less so in Run 4 (phosphoric acid used), but much more marked in Run 6, because here the sulfured juice was limed almost to neutrality. This, according to Schneller, produces a darker juice, because high acidity, as used in the other runs, decomposes the ferric polyphenol compounds with a corresponding lightening in the color. In Runs 2 and 5, on the other hand, where carbon was used, the total color was reduced very considerably, and not increased like in the other runs. This in itself constitutes a strong argument in favor of carbon.

From clarified juice to syrup, and from this to first molasses, the total color increased in all of the runs. This shows that new coloring matter is formed, because it increases faster than the total non-sugars. The rate of increase was quite considerable in Runs 1, 3 and 6 (straight sulfitation without carbon), less so in Run 2 (straight sulfitation with carbon), still less in Run 4 (sulfitation-phosphatation without carbon), and least in Run 5 (sulfitation-phosphatation with carbon). It appears, therefore, that from the standpoint of total color not only the use of carbon, but also that of phosphoric acid is commendable.

The lasting effect of the carbon treatment was shown very strikingly by the fact that the total color increased much less from raw juice to molasses in those runs where carbon was used than in the corresponding ones, where it was not.

In Run 6 the total color of the carbon-treated syrup was found to be very much lower than that of the untreated, again showing the favorable effect of the carbon.

Ferric iron was higher in the raw juice of the first two runs than in the others, evidently because the mill had not been used for almost a year and rust dissolves more readily in cane juice than does metallic iron. The high iron content in the second raw juice was partly due to stoppages on account of breakdowns in the mill. From the raw juice to the clarified juice the ferric iron increased in all those cases where no carbon was used, and decreased in those where it was employed. This is due to the fact that between the mill and the clarified juice tank the juice takes up more iron, from the machinery and the lime, than is removed by the ordinary process of clarification; but where carbon was employed, so much iron was actually removed, in spite of all the juice being passed through the filter-press with its large iron surfaces, that the clarified juice really contained less iron than the mill juice.

From the clarified juice to the syrup and to the molasses the iron increased rapidly, for reasons already stated. In fact, it rose much more rapidly than the concentration. But even in the molasses of those runs where carbon was used in clarification, the iron was still quite a bit lower than in the others.

A comparison of the ferric iron in all the products of Run 1 with that of the other runs brought out a very interesting fact. Harloff and Schmidt state that "at the commencement of the campaign the first sugars will assume a gray or yellow tint which, according to researches conducted with this object in view, owes its origin to suspended impurities in the juice derived from insufficiently

cleaned apparatus or pipes, and not, as was formerly supposed, to some insoluble coloring substance or iron." We found that this conclusion does not hold true in all cases. The ferric iron in Run 1, first molasses, was about two and a half times as high as that in Run 3, which was the next highest.

In the treatment of syrup with carbon in Run 6, the ferric iron was also reduced to some extent, just as happened in the juice treatment, but the decrease was not nearly as pronounced as the reduction in the total color.

Total iron. This is of less importance than the ferric iron alone, for reasons already explained. We might say that the ferrous iron has to be considered only inasmuch as it gives us a measure of the potential quality of ferric iron which would be present after oxidation of all the ferrous iron to the ferric form. In comparing the figures for total iron, about the same observations were made as with the figures for the ferric iron.

Polyphenols. The results obtained for these compounds were of particular interest. The polyphenol content of raw juice was highest in Runs 2 and 5; that is, before any treatment whatever. These were exactly the two runs in which we ground a large number of small samples of seedling varieties, many of which were quite poor, and their polyphenol content was so pronounced that it affected the average. These findings confirm again the observations of Browne and Schneller, to the effect that unripe cane is higher in polyphenols than is ripe cane.

In the process of clarification the polyphenols are invariably reduced. But here again the use of carbon shows its great efficacy. In spite of the fact that the initial polyphenol content in the raw juices of the carbon, Runs 2 and 5 happened to be higher than that in any other run, the polyphenols in the clarified juices of the same runs, 2 and 5, were ever so much lower than in the others.

The changes in polyphenols from the clarified juice to the syrup proved likewise very interesting. In all cases where no carbon was used there was an increase from clarified juice to syrup, but a decrease in those runs where carbon was added to the other clarifying agents. This is probably partly due to the fact that certain compounds (saccharetin?) which give rise to polyphenols upon heating are removed by the carbon, so that the effect which they would otherwise exert is also prevented. But this would not explain an actual decrease between clarified juice and syrup. It would seem that some polyphenols are decomposed by heat and others are formed. A rise or fall would, then, occur according to the preponderance of one reaction over the other. As a rule the formation of new polyphenol compounds (pyrocatechin?) seems to exceed the destruction of others. In all of the molasses, excepting that of Run 1, the polyphenol content was higher than in the syrup, owing evidently to the formation of new ones.

In the syrup of Run 6, the carbon caused a very large reduction in the polyphenols, showing again the efficiency of the carbon in this respect.

All the results clearly demonstrated that the color does not change parallel with the polyphenols themselves, while there was indeed found a certain parallelism between the color and the ferric and the total iron. The significance of this will at once become apparent in the following discussion:

Ferric polyphenol compounds. Although the clarified juice in Run 1 had

less polyphenols than the raw juice, the iron was so much higher that it raised the ferric polyphenol compounds, and also the total color above that of the raw juice. The same is true of Runs 3, 4 and 6, all of which were without carbon. But in Runs 2 and 5, where carbon was used, the ferric polyphenol compounds in the clarified juice were less than in the raw juice, as were also the polyphenols, ferric and total iron, and total color.

The importance of the combined effect of iron and polyphenols was strikingly shown by the fact that the color caused by the ferric polyphenol compounds was found to be in a nearly constant proportion to the total color, excepting in Run 6, where the low acidity explains this discrepancy. Moreover, there was shown a remarkable constancy in the direction of the changes of ferric polyphenol compounds and of total color. In seventeen cases out of a total of eighteen changes, a decrease in one means a decrease in the other, and an increase in one is accompanied by an increase in the other. So far we have not been able to determine what percentage of the total color is due to the ferric polyphenol compounds, but expect to solve this question also as soon as we have a sufficient quantity of cane polyphenol on hand. For the present we must content ourselves with knowing that the total color generally increases and decreases with the ferric polyphenol compounds.

The effect of the carbon was again demonstrated by the fact that there was not only a reduction in total color and in ferric polyphenol compounds where it was used, and an increase where it was not, but the total range of change in all the products was within much smaller limits, and of smaller magnitude throughout in Runs 2 and 5 than in the corresponding ones 3 and 4.

Sugars. The figures for the various non-sugars in the first sugars generally lay between those for the clarified juices and those for the syrup of the same run. The total color and, as was to be expected, also the ferric polyphenol compounds, were higher in the sugars from Runs 1 and 3 (no carbon) than in Run 2 (carbon), and higher in Run 4 (no carbon) than in Run 5 (carbon), although the figures for ferric and total iron did not so parallel at all with them. They happened to change in the same direction as the polyphenols themselves, because in the sugars, like in the molasses and some of the syrups, the ferric iron was in excess of the polyphenols with which it could combine.

For this reason the ferric polyphenol compounds changed qualitatively like the total color and the polyphenols, and from a quantitative standpoint the changes in the ferric polyphenol compounds agreed most closely of all with the total color. This proves again the large part played by these compounds in the total color of the products, and confirms our observation with the other products.

The results obtained on the sugars also corroborated an observation made by Prinsen Geerligs, who found that the color of the sugars is darker than it should be, if it were all contained in the surrounding molasses film. This holds true for our sugars also, but to a smaller extent.

So far we have dealt only with the color of the products, and certain constituents of it. These have proven the efficiency of decolorizing carbons from this point of view; but we are naturally just as interested in the yield of the sugars obtained by the use of carbon, as compared to that made without its use.

Looking at the question from this standpoint we found that the purity of

the raw juice in Run 2 was 3.6 points lower than that of the raw juice in Run 3. But in the clarified juice this difference had narrowed down to 2.8 points, on account of the fact that the clarification, plus carbon treatment, gave an increase in purity of 1.0 while clarification without carbon gave one of only 0.2. In the syrups the difference in purities became still smaller, amounting to only 2.3 points. The same observations were made in comparing Run 2 with Run 1, which was made in the same way as Run 3.

Comparing Run 4 (without carbon) and Run 5 (with carbon), we again found a difference in the purity of the raw juices of 0.9, which narrowed down to 0.3 in the clarified juice, amounting to nothing in the syrup. The results in both sets, therefore, agree well with those obtained in the 1917 tests.

The glucose ratio was not affected to any extent by the carbon treatment, which likewise confirms previous results.

The drop in purity from syrup to first molasses was 21.8 points in Run 2, 20.5 points in Run 3, and 17.3 in Run 1, a difference of 1.3 and 4.5 points in favor of the carbon run. In Runs 4 and 5 the differences were smaller, only 0.2 points in favor of the carbon run, undoubtedly because the purity of the two syrups was the same. Mr. Taggart noticed again, as he had in 1907, that the carbon-treated products boiled more freely than those not so treated. This is also in line with the observations made by Peck and Adams when using the molasses carbon mentioned before. The yield of sucrose in the form of first sugar, calculated on 100 parts sucrose in the syrup, was 57.3 in Run 1, 62.6 in Run 2, 62.1 in Run 3, 58.6 in Run 4, and 59.0 in Run 5. Slightly better yields were, therefore, obtained from each of the carbon-treated products than from the untreated, in spite of the fact that the raw juices were poorer in each case. The glucose ratio also rose less, from syrup to molasses, in Run 2 than in Run 3, and less in 5 than in 4. This fact shows again the better quality of the carbon-treated products.

The quality of the raw sugar, made in each case without the use of wash water in the centrifugal, was better in Run 5 than in Run 4, the former having 95.1 per cent sucrose, and the latter only 93.7. In Runs 2 and 3 the result was different, owing no doubt to the fact that the purity of the syrup in Run 2 was still considerably lower than in Run 3, and also that the massecuite in Run 2 was boiled much stiffer. For this reason the massecuite of Run 2 did not purge as well as that of Run 3. Sugar No. 2 has 90.7 per cent sucrose, and sugar No. 3, 93.7 per cent. It is certain that under more equal conditions the sugar of Run 2 would have been at least as high in sucrose as that of Run 3.

The results obtained in our experiments show that the combination of ferric iron and polyphenols indeed plays a very important part in the color of our sugar-house products. If it is desired to make a light-colored sugar, it is necessary to keep both iron and polyphenols at a minimum. The former condition can best be accomplished in actual practice by working as rapidly as possible, and by not leaving any of the products in contact with iron surfaces any longer than is absolutely necessary. As Schneller has pointed out before, iron machinery might to advantage be largely replaced by copper, especially in those countries where the sugar factory is in use all the year around. In certain cases it might pay to make raw sugar during the campaign, and afterwards refine this by the

use of decolorizing carbon in connection with a copper pan. It would also be advisable to paint all iron machinery wherever possible with iron-free paint which should be quite resistant to the effect of acids, alkalis and heat. When boiling out with caustic soda, a solution of the desired strength should first be prepared so that the iron or painted surfaces do not come in direct contact with solid caustic or strong lye. Iron in the products may also be largely reduced by the use of decolorizing carbon.

The polyphenols are removed only to a slight extent by the ordinary methods of clarification used in white sugar manufacture in Louisiana. Decolorizing carbons are, however, very effective in taking out polyphenols, and also other compounds which in the course of manufacture give rise to new polyphenol compounds. If a sufficient quantity of an active carbon be used, the polyphenols, the iron combined with them, and also the mother substances of polyphenols may be removed practically completely. The question as to how far one may go economically in this respect will of necessity have to be determined by actual factory tests on a normal scale.

Our tests have further demonstrated that the yield of sucrose in the form of first sugar is not smaller, but even slightly better where carbon is used than where it is not. But of even greater importance is the fact that the use of carbon produces a first molasses of much lighter color. The significance of this has been pointed out by Harloff and Schmidt. It would not naturally be expected that a molasses of light color will give a light-colored sugar as well, and that therefore a larger quantity of high-grade sugar could be made by boiling back such a light-colored molasses. Experiments on this particular point are contemplated for the coming grinding season at our sugar house.

It is evident that the results obtained at this Station warrant tests on a larger scale on the part of our sugar planters, and the hope is again expressed that at least some of them will be sufficiently interested to undertake this work at the earliest possible moment. The fact that the assistant director of this Station has finally succeeded in securing the free use of decolorizing carbon from rice hulls for the public, should be a further incentive in this direction.

3. DETERMINATION OF ASH IN CANE SYRUPS AND MOLASSES.

Since there is a possibility that the percentage of ash in syrups and molasses may, in some way or other, play a part in the official food standards to be established for these products, it seemed advisable to carry out a comparative study of the methods for the determination of ash, as adopted by the Association of Official Agricultural Chemists. There are at present three such methods, all of them official. The two principal questions to be settled are: First, which of the three methods yields the most concordant results in the hands of different analysts; and, second, how well the results obtained by the three methods agree with one another. The first of these questions appears to be the more important from the standpoint of food control, although the second should also be settled as well as can be done in a matter involving the determination of a constituent as vaguely defined as "ash." For the present we shall call "ash" that part of a substance which remains after heating it in the presence of air to a temperature

high enough to destroy its organic constituents or convert them into carbonates, but not sufficiently high to volatilize the inorganic constituents to any extent.

In order to get an answer to the first question stated above, and at the same time some information on the second, three samples of genuine cane products—a syrup, a first molasses, and a final molasses—were sent out to a number of chemists who had expressed their willingness to cooperate. These chemists were requested to determine the ash in these products by the three official methods, which may be shortly characterized as follows: (1) Direct incineration, without and with the use of ammonium carbonate; (2) carbonization, leaching out soluble salts with water, ashing insoluble part of char, adding leachings, evaporating to dryness and ashing again. Ammonium carbonate to be used in one set, and left out in the other; (3) carbonization with varying quantities of concentrated sulfuric acid, and ashing.

Ten analysts reported results on all or part of the samples, and the tabulation of the results enabled us to make some interesting observations. It was found; in the first place, that while duplicate results obtained by one and the same analyst checked very closely, there was a wide divergence between the results found by different analysts. This was attributed to the probability that the various analysts used different temperatures in the incineration, and a recommendation was made that in further work the influence of various measured temperatures be studied. It was further shown that, contrary to general opinion, the sulfated ash method has, from the standpoint of close agreement between different analysts, no advantage over the direct ash method with the use of ammonium carbonate. In the experience of the writer it even has usually no advantage from that of ease of manipulation. Only in those cases where it is impossible to burn off the carbon by direct incineration can the analysis be done more easily by the use of the sulfated ash method. It has furthermore been confirmed, that the correction factor of 10 per cent, officially adopted by the Association of Official Agricultural Chemists, is far from the truth. In seven different products analyzed, comprising syrup, first, second and final molasses, the correction factor was found to vary from 16.4 to 22.3 per cent, and averaging around 19 per cent. Further work on this point, covering a greater variety of samples, has been recommended.

Mr. E. C. Freeland is joint author of both the bulletins to be published shortly by the Station, and Mr. D. D. Sullivant also assisted in the work reported here. The writer's thanks are due to both of these gentlemen.

[W. R. M.]

Keeping Soils Productive.*

THE PROBLEM OF MAINTAINING FERTILITY IN THE LOUISIANA CANE BELT.

By STANLEY F. MORSE.

THE SOILS OF THE CANE BELT.

Most of the sugar cane in the United States, not including our insular possessions, is produced in a narrow strip of territory close to the Gulf of Mexico. In the States of Louisiana and Texas the best sugar cane soils are low, rich, alluvial lands, found along the Mississippi river from Baton Rouge south and west near the Southern Pacific Railroad to Texas. In Texas fertile lands near Brownsville and Sugar Land are devoted to sugar cane. Practically all of these soils have been laid down by water action, most of them being river deposits. They are naturally of great fertility, and some of them have been cropped for over 100 years and are still producing fair yields of sugar cane.

The principal types of soils found in this region are commonly designated as follows:

"Sandy land," which is an easy working silt loam and is preferred by sugar planters for cane. This type of soil is generally found in well-drained locations and requires less team power to work than the other types.

"Mixed land." This is really a clay loam which is very productive as long as the physical conditions remain good.

THE LOUISIANA BLACK LANDS.

"Black land." The technical name for this is "sharkey clay." It is a stiff clay soil deficient in humus and usually found in poorly drained locations. Although it is very heavy and difficult to work, this soil is rich in plant food and when well drained and thoroughly loosened by organic matter and deep tillage, it will produce excellent crops of cane. However, black land is not liked by sugar planters, as it is ordinarily hard to work and unreliable as a cane producer. Most planters avoid using this type of land for cane, but some of the prejudice against it would disappear if the planters once found out how to handle it. Since most of the plantations have more or less black land, it is desirable that more attention be paid to bringing this land into a better state of cultivation, although some of the planters are solving this problem by planting rice on it.

Occasionally gravelly or light sandy soils of a leachy sort are found, but these are not well adapted to cane because they do not retain the moisture. Another kind of soil which promises to come more into general use for sugar cane is the muck soil. In Louisiana and Florida there are great areas of swamp lands which are being brought under cultivation by drainage. When they have been thoroughly drained and the natural growth of grasses and other

* Facts About Sugar, Vol. VIII, April 5, 1919.

plants has been subdued, sugar cane will grow luxuriantly on these soils. However, there are two difficulties which must be overcome in growing cane on muck lands. In the first place, muck soils are apt to be sour and the acidities which they contain must be washed out of the land by good drainage before attempting to grow sugar cane. In the second place, these soils have an excess of nitrogen and a deficiency of mineral elements which tend to produce a rank growth of cane with a low sugar content. The difference between the average analysis of Louisiana sugar soils and the muck lands of Florida shows why this is true. Following are the analyses:

Soil	Nitrogen per Cent	Phosphoric Acid per Cent	Potash per Cent
Louisiana	0.10	0.10	0.40
Florida	2.56	0.18	0.08

By looking at these analyses, it may be readily seen why it will be necessary to apply phosphoric acid and potash in chemical form to balance the excess of nitrogen. Dr. Rose suggests the use of 500 lbs. of 16 per cent acid phosphate and 50 lbs. of actual potash per acre as a minimum application. It may be added that rock phosphate could possibly be used to advantage on these soils as a cheap source of phosphoric acid. It scarcely pays to use lime to counteract the acidities of these soils on account of the immense quantities that would be required. Also, as previously mentioned, drainage removes a great deal of the acidity and sugar cane is not so susceptible to an acid soil as are certain other crops. With the proposed development of certain Florida muck lands for the production of sugar cane, these matters are of special interest at the present time.

Mention should also be made of muck soils which are underlaid with silt, clay or marl at a depth of a few inches to several feet. When the solid sub-soil is close to the surface such a muck soil is very desirable.

Still another type of soil on which sugar cane is commonly grown, although mainly for syrup, is the cut-over pine land clay. Usually these soils require building up with humus and plant food before they will give heavy yields of cane.

FACTORS IN SOIL FERTILITY.

The point which this article is intended to discuss, however, is not so much the character of the sugar soils of the South as how their fertility may be maintained. The great tendency of single crop farming is to crop rich land continuously until it no longer produces profitable crops and its fertility has been so reduced that it will require several years to bring it back. The first thing the sugar planter should understand is that soil fertility is not a matter of chemical plant food alone. A soil may contain the essential elements of plant food in great quantity, but will not produce large crops unless the physical condition and the drainage of the land are first class.

By physical or mechanical condition is meant the texture of the soil. Thus a soil which is compact and sticky, or so loose that it will not hold the moisture

well, is in bad physical condition to produce maximum crops. Three things must be present before the plant food can be made available for plants: First, there must be sufficient water, but not too much. Second, the beneficial bacteria, which change unavailable chemicals to valuable plant food, must be present and thoroughly active. Third, the plant roots and the bacteria must have air.

SOIL DRAINAGE AND TEXTURE.

It will be readily seen that a waterlogged (poorly drained), or a very compact soil, will contain so much water that the bacteria will be drowned and air excluded from the soil, or the compactness of the soil will exclude the air from the bacteria and the roots and will prevent the roots pushing out in search of food. On the other hand, a very loose soil will not hold enough moisture to keep the plant food in solution to feed the crop, which will suffer from drought and starvation. Also, in a loose soil, the bacteria do not thrive so well.

It will, therefore, be readily understood why the application of fertilizers to soils in poor physical condition will not materially increase crop yields and give results commensurate with the expenditure of money. It is evident that the physical condition of the land must be improved before paying too much attention to the supplying of plant food.

As already pointed out, the bad physical condition in which soils are commonly found may be due either to poor drainage or to a lack of humus in the soil. Poor drainage may be due either to natural conditions which must be remedied by thorough ditching to communicate with the natural drainage, which means a gravity system; or where the natural drainage is lacking and the water table is high, it may be necessary to construct levees to hold back the water and to install powerful pumps connected with the ditch system which removes the water from the ditches and carries it over the levee which keeps the water from backing up into the ditches.

Some plantations are fortunate enough to have good natural gravity drainage, either by having a good fall into some stream or by being located in a drainage district. Other sugar properties have to use the more expensive method of pumping plants which must be operated whenever a heavy rain occurs. However, when the ditches are not kept properly cleaned, a costly annual operation, the land may become waterlogged and its producing power diminished. Sometimes the ditches are not placed close enough together in heavy land, with the result that only partial drainage is secured. Of course, most of the foregoing conditions may be remedied, and thorough drainage will make a surprising difference in the physical condition of an apparently non-productive soil.

In connection with the drainage problem, there is an opportunity for increasing production and decreasing the cost of maintenance and operation. One possible method of improving present conditions is by the use of drain tiles. Several years ago some tile drainage was done on various sugar properties, but the results were not favorable, apparently because the engineering work was not properly done, tile of large enough size not having been used and the tiles not having been laid to grade. Also, it is possible that the tiles were not laid close enough together. The general opinion of planters and engineers regard-

ing tile drainage is that the soils usually are of such a compact nature that water will not penetrate to the tiles, and that the rainfall is so heavy (single rains of from two to four inches at a time sometimes occurring) that the tiles cannot carry off the water fast enough. It is also stated that the tiles have a tendency to fill up with silt and become useless.

TILES SUCCESSFUL ELSEWHERE.

It is true, however, that heavy clay lands of the most refractory sort have been successfully tile drained in the Middle West; tile drainage has also been used in Porto Rico in the section where the rainfall is fairly heavy. Furthermore, it is well known that where tiles are laid with proper grade and with cleanout boxes the trouble from filling up with silt can be overcome. It seems to be the belief of drainage engineers that tile drains will work in the regions of heavy rainfall in light silt soils and in muck land.

The United States Department of Agriculture, in cooperation with a land owner, installed a year ago a tile drainage system on nine acres of light silt land near Donaldsonville, La.; this installation has worked in a very satisfactory manner during the rainiest season that has been recorded for fifty years. It is the belief of the writer that a large percentage of the "front" lands in Louisiana, which are composed of the lightest types of soil, could be generally tile-drained and the open ditches eliminated. The saving secured in this way would be about one acre of land for every sixteen acres.

The cost of installing the tile drainage referred to was about \$60 per acre. Assuming that the average piece of land divided by ditches is 165 feet wide by 1050 feet long, its area will be about four acres and the land wasted by open field ditches will be one-fourth of an acre. The cost of tilling the four acres would be \$240 and the interest on this investment at 10 per cent would be \$24. Figuring a yield of 20 tons of cane per acre, the reclaimed one-fourth acre would yield five tons of cane, which, at \$7 per ton, would give \$35. This, added to the eliminated cost of ditch cleaning, would pay a good profit above the interest on the money invested.

PANEL DITCHES WASTEFUL.

Besides the waste of land which occurs in the regular field ditches which lead toward the drainage outlet, there is more wasted land in the "panel" ditches which run out at right angles to the others. These panel ditches were largely constructed as the land was reclaimed from the swamps. Thus a certain tract of land would be leveed off from the swamp and put under cultivation. Later an area of land behind the first would be similarly leveed off and reclaimed. This would leave a ditch between the two tracts of land, and gradually, as the land was reclaimed back into the swamps, there was left a series of panel ditches which served no useful purpose.

ELIMINATING PANEL DITCHES.

Reference has been made to the waste of land involved in the use of "panel" ditches in plantation drainage.

Many of these panel ditches could today be eliminated and some plantation

owners are planning to do this in spare time. Not only would the eliminating of the useless panel ditches bring under cultivation from 10 to 40 acres for every thousand under the plow, but it would be possible then to work the land in long rows, eliminating frequent turns and reducing the expense of tillage. This arrangement would also tend to favor a greater use of tractors which are now obliged to work in limited areas. The increased profits per year due to eliminating the panel ditches could be for each 1000 acres from \$500 to \$2000. The elimination of ditches will also help to eradicate weeds and insect pests which are harbored in the vegetation growing on the ditch banks.

After the drainage has been made as efficient as possible, attention should be given to the humus supply of the soil. This does not mean that all soils which are deficient in organic matter necessarily have poor drainage also. The fact which the average southern sugar planter does not yet fully realize is that the heavy rainfall and the abundant and long continued heat greatly stimulate the action of the bacteria which assist in the decomposition of organic matter. The direct rays of the sun, as well as the bacteria, destroy humus very rapidly and the heavy rainfall washes and decomposes humus out of the soil, thus depriving it of the most essential element for keeping it in prime physical condition.

LOSS GREATEST IN TROPICS.

As one goes from the sub-tropics into the tropics this destruction of humus becomes much greater and is one of the most serious problems to be contended with in the maintenance of soil fertility. The University of California announced several years ago that it had discovered that the destruction of humus in the soil was so great in certain orange groves, where the matter had been studied, that it was almost impossible to replace it rapidly enough by any ordinary means.

The importance of humus to the soil lies not only in its making the soil work easily and cheaply, but also in the fact that it is the home and food of beneficial bacteria; it greatly increases the ability of the soil to hold moisture and plant food and permits air to penetrate to plant roots and soil organisms. The value of humus in maintaining the fertility of the soil can scarcely be over-estimated and a large majority of the soils which have become non-productive through constant cropping and abuse are suffering more from lack of humus than from any other cause. It is useless to try to substitute lime or fertilizers for organic matter in building up run-down or heavy soils. The planter must get at the root of the trouble by replenishing the supply of humus in a systematic and economical manner.

SOURCES OF HUMUS.

The best sources of humus, or decayed organic matter, are green vegetation, such as legumes grown for the purpose, crop residues, or weeds, and stable manure, straw, and filter-press mud. The use of green manure crops for improving sugar soils has been practiced for many years in the sugar belt of the South, but generally planters have been so stingy in plowing under the cowpeas.

which are planted in the corn at laying-by time, that the full value of this system has not been secured and soils have continued to run down.

The usual system in theory is to plant cane, allow it to stand for a stubble crop, and then to plant corn the third year with peas between the rows. The peas are supposed to be plowed under to improve the land after the corn crop has been harvested and cane is then planted on this land.

In practice a considerable quantity of the pea-vines is harvested each year for hay to feed the mules and probably not more than 20 per cent of the manure made by the mules ever finds its way back to the fields again. In this way much of the benefit of the pea-vines is lost, except where a piece of land becomes especially poor and a planter turns under a full growth of pea-vines or sometimes plants corn and peas two years in succession in order "to bring the land back."

ONE PLANTATION'S PRACTICE.

Recently a large group of properties under the writer's supervision has adopted a policy of raising all the necessary hay for the mules on special land and of plowing under all the peas produced with the corn. This practice is already showing good results. One crop of peas grown every third year in the rotation cannot supply enough nitrogen to meet the crop's needs, and it is doubtful whether this system will maintain the humus requirements of the soil, especially where the cane trash is burned. That this system is not entirely adequate is proved by the fact that sugar planters who use this third-year rotation average about 20 tons of cane per acre, while small planters who have adopted a four-year rotation where two crops of peas are plowed under in succession average nearer 30 tons of cane per acre.

One large plantation reports that, after changing its cropping system from two-thirds the area in cane and one-third in corn to one-half in cane and one-half in corn, its total cane production is just as large as ever and it has corn for sale where previously it barely had enough for its own use.

The writer believes that this rotation of two years cane and two years corn and peas may be improved on by substituting for one year of corn and peas a crop of velvet beans planted between rows of corn twelve feet apart. On one plantation the writer found that velvet beans plowed under on poor land gave a yield of nearly 24 tons to the acre, while peas plowed under in the same field and fertilized with 500 pounds of tankage gave only 12 tons of cane per acre. As a result one plantation of 800 acres which is badly run down is being cropped with half its area in cane, one-fourth in velvet beans and one-fourth in corn and peas.

TRASH SHOULD BE PLOWED IN.

Again, tops and trash which are commonly burned to clear the land and to get rid of the borer, should be plowed under so far as possible, to add to the humus supply. It has recently been found that the parasite which controls the borer hibernates in this trash, and that burning destroys the parasite as well as the borer, thus really favoring borer increase. Therefore, plowing under trash will not only add organic matter to the soil, but will also aid the control of the borer. Of course, in some seasons, it may not be possible to bury this trash

early enough so that it may decompose, but this should be done as far as possible. It was discovered a few weeks ago that by using a tractor to break stubble and cover the trash this work could be done more effectively than by the use of mules, owing to the greater speed of the tractor.

FEEDING TRASH TO CATTLE.

Another phase of the trash disposal, which will be developed at greater length later on, is the use of the green tops and leaves for silage to be fed to beef cattle from which the manure produced will go back on the land, and the use of dry trash as bedding in stable sheds with dirt floors, where it will be mixed with the manure and go back on the land.

Where the plantation is connected with a sugar house, the filter-press mud will be found of considerable value for adding humus to the soil as well as nitrogen and some mineral plant food. Care should be taken to fully utilize this valuable substance which the writer believes is almost equal to stable manure. The main difficulty with filter-press mud is its high moisture content and the fact that it is produced at a time of year when the land is apt to be wet and difficult to haul on. A method of diluting this substance with water and pumping it onto the land has been tried with partial success. Probably a better plan will be to construct a shallow concrete pit into which this material may be pumped or deposited by a carrier, where it may be allowed to evaporate some of its moisture and get into such mechanical condition that it may be easily distributed by manure spreaders at a favorable time. The writer has seen exceptionally heavy crops of corn and cane produced where filter-press mud has been used.

WEEDS AS A SOURCE OF HUMUS.

In addition to this substance, weeds are mentioned as a source of humus, but this does not mean that it is advisable to allow weeds to grow in order that they may be plowed under to improve the soil. The point which the writer wishes to make is that weeds and similar trash should be plowed under wherever possible instead of using the all too common fire as a means of clearing the land. Every year thousands of tons of invaluable organic matter may be seen rising to the heavens as smoke.

Mention should also be made of a new possible means of adding humus and nitrogen to cane land. The Louisiana Sugar Experiment Station has secured increased yields of as much as two tons of cane per acre by sowing sour clover (*Melilotus indica*) and crimson clover on top of the rows of fall-planted cane. These clovers make a rapid winter growth and are plowed under in the spring. This method of adding to the soil humus is worthy of further attention and trial.

The Normal Sugar Weight.*

Since shortly after the beginning of the war, it has been impossible to obtain polariscopes, and an American firm has undertaken to manufacture these instruments. The preponderance of opinion among chemists, to whom the question has been submitted, has been in favor of making these instruments for use with a twenty gram normal weight.

Some objections have been raised, however, and we print in this issue the arguments for and against the change.

SHALL AMERICA ADOPT A NEW STANDARD AS HAS BEEN SUGGESTED?

By FREDERICK BATES.

During the past few months much has been written and many discussions have taken place relative to a suggested change in our present value of 26 grams for the so-called normal sugar weight. The new value suggested is 20 grams. In proposing this change advantage has been taken of the current situation regarding the present and future supply of saccharimeters for the sugar industry of the Western Hemisphere. The importance and desirability of producing a supply of saccharimeters in the United States has again been brought to the attention of the manufacturers of optical instruments; and in view of the fact that there is immediately in sight a demand for a considerable number of instruments, various manufacturers have become more or less actively interested in their manufacture.

WHY CHANGE IS URGED NOW.

Fortunately, during the past year, the Bureau of Standards has succeeded in reproducing practically every step needed in the manufacture of the optical parts of a precision saccharimeter, and has placed this information at the disposal of all concerns interested in the production of an American-made polariscope. Inasmuch as it may be some time before the foreign-made saccharimeter is again available, it has been suggested by the proponents of a change in the normal weight that American producers build their instruments with scales requiring calibration on the 20-gram basis.

In the present effort to show a consensus of opinion among American sugar chemists in favor of the proposed normal weight, statements of the views of various individuals on the suggested change have been collected. As a result of this canvass it has been published that the replies received have for the most part been very favorable to the 20-gram weight. It hardly seems possible that an unbiased expression of opinion could be obtained under such a procedure. The subject is from any point of view an exceedingly technical one regarding which few of us have ever had occasion to make a special study. Thus, most

* Facts About Sugar, April 19, 1919.

of us are in a position where we have been presented with a sort of symposium, as it were, in favor of the 20-gram weight; which would enable us to dispose of the matter by saying yes. Whereas, if we were inclined to consider thoroughly the objections to such a change we should practically be compelled to create our own arguments.

In suggesting the change to 20 grams the nearly undefended 26-gram weight has been stigmatized by being referred to as the German normal weight; and the intimation is made that by adopting the 20-gram weight there will be restored to France an industry in which she was predominant many years ago. This argument is apparently based upon the fact that a French manufacturer of saccharimeters states that he is willing to build instruments graduated for 20 grams; whereas he has never been willing to build instruments graduated for 26 grams. Just why arguments of this character should be presented to American sugar chemists to bring about such a momentous and far-reaching effect is difficult to appreciate or understand.

In addition to what, for lack of a better term, may be designated arguments of nationalism, attention has been directed to the fact that at the Second International Congress of Applied Chemists, D. Sidersky, actuated by a realization of the importance of obtaining a real international normal sugar weight, suggested the compromise value of 20 grams. Contrary to a recent published statement that no action was taken by the Congress, it voted¹ down the proposition, owing to the decided sentiment in favor of retaining the French normal weight of 16.19 (subsequently 16.29) grams.

ARGUMENTS FOR CHANGING.

The following arguments in favor of the new standard proposed have been recently prepared by those who advocate discarding the present normal sugar weight of 26 grams:

(1) The 20-gram scale being a compromise between the French 16.29-gram scale and the German 26-gram scale is free from all national bias. (2) The results obtained with the 20-gram normal weight are easily converted into percentages by multiplying by 5, while the results obtained by the French or German normal weights are not thus easily transformed. (3) Aliquot portions of 50, 25, 20, 10 and 5 cc. of the 100 cc. international scale normal solution represent even gram quantities (10, 5, 4, 2, and 1 gram, respectively), which is not the case with the French or German standards. (4) The specific rotation of sucrose at a concentration of 20 grams in 100 cc. (18.62 per cent) is about the maximum, while it is perceptibly lower at concentrations above or below this amount. (5) A 20-gram normal weight is always available as a one-piece unit in the analytical set. The French and German normal weights are not always available as one-piece units, and to make up the quantity from an analytical set of weights is inconvenient as well as open to error. In addition to the above a sixth reason has been added: "The 20-gram normal weight, its fractions and multiples, are always available as one-piece units in the analytical set."

¹ Deuxieme Congress International De Chimie Applique, p. 522.

BASIS OF CLAIMS.

If we neglect No. 1, which is obviously true for any new normal weight that might be selected, it will be observed that of the five remaining advantages three are based upon an objection to using the multiplication and division tables.

In our experience, we have never heard these arguments advanced by a practical sugar chemist as a serious objection to the use of the 26-gram weight. Most of us are called upon but seldom to utilize any weight but the double normal, normal, or half normal. Those chemists who are regularly carrying on routine work in which it is necessary to multiply and divide the figure 26, commit to memory in a few moments the results which are obtained by frequently recurring multiplications and divisions. Thus, while it might be more or less of a convenience to have all such operations performed in the easiest way possible, no objection to the use of the figure 26 in this connection could be considered as of more than secondary importance.

Advantage No. 4 is past understanding so far as any practical importance is concerned. The circumstance that the variation of specific rotation with concentration is of such a character that the specific rotation happens to be a maximum in the vicinity of 20 grams is of little consequence. This is established by the fact that for either 20 grams or 26 grams the maximum scale error from this cause is considerably smaller than the accuracy with which the specific rotation concentration curve is known.

INCREASES ERROR MAXIMUM.

However, it is interesting to note that, from the best available data, the present normal weight of 26 grams gives the saccharimeter scale a maximum error of 0.015 sugar, due to the variation in the specific rotation. This occurs at 80° sugar. With a normal weight of 20 grams the maximum error due to the same agency would occur at lower polarizations. For a 96° sugar the scale error would be 0.004 sugar for 26 grams and 0.0015 sugar for 20 grams. Obviously the proponents of a 20-gram normal weight have used (4) without investigation of its real significance.

Advantage No. 5 argues that in the event that a normal or half normal weight is not available, the 20-gram weight can be utilized from a regular set of weights, whereas it is necessary to use several weights to make up the 26-gram normal weight; and it is argued that the latter is inconvenient and open to error. The necessity of making up a 26-gram standard from a set of analytical weights so rarely occurs in any sugar laboratory that we have never heard any complaint regarding its inconvenience. To argue that this procedure is open to error is difficult of comprehension, inasmuch as the accuracy of our analytical weights is to a very considerable degree greater than the accuracy with which any other step in the analytical work on sugars can be carried out.

ARGUMENTS AGAINST CHANGE.

It is a lamentable commentary that it should be necessary to spend time refuting arguments of the character of those which have been presented for the purpose of bringing about a thing so momentous to the industry as a change in the normal sugar weight. In contrast to the six advantages given above there

could be enumerated a relatively large number of arguments in favor of retaining our present normal weight of 26 grams. However, for the sake of simplicity, they may be summed under three general statements:

(A) The inconvenience and confusion incidental to having two standard normal weights and two sets of sugar tables in use at the same time would be great.

(B) A reduction in the normal weight will give approximately a corresponding reduction in the accuracy with which saccharimetric measurements can be made.

(C) The international situation, so far as the normal weight is concerned, would be rendered almost chaotic.

Any one of these it seems should be far more than sufficient under the present conditions to counterbalance the six advantages enumerated above.

Regarding (A), it would seem almost unnecessary to elaborate. The life of the average well-made saccharimeter is of long duration. It has been suggested that the thousands of instruments now in use be rescaled; and that the consequent reduction in accuracy due to the unavoidable shortening of the scale, could be overcome by increasing the magnification of the scale. I believe it will be admitted by anyone familiar with saccharimeter construction that it is physically possible to rescale these instruments, retaining the old quartz wedges, yet practically it would never be done; and to argue that the loss in accuracy due to the shortening of the scale could be overcome by increasing the magnification of the scale is to argue invalid the accepted rudiments of linear measurements.

INCONVENIENCE OF DUPLICATION.

The ordinary metal scale which is necessarily read by reflected light, needless to say, is already magnified to the limit. Mere magnification does not increase the accuracy with which a scale can be read unless the lines of the scale are sufficiently delicate to permit of utilizing the higher resolving power. It is, therefore, apparent that sugar laboratories would be compelled either to discard the apparatus now in service, or to operate handicapped by the disadvantage of having two normal weights, two types of saccharimeters with different bases of standardization, and two sets of sugar tables.

Relative to (B), it is perhaps unnecessary to state as an axiom that any diminution in the magnitude of a quantity to be measured necessarily results in a corresponding reduction in the percentage of accuracy with which that quantity can be measured. Consequently, a reduction in the normal sugar weight will give approximately a corresponding reduction in the accuracy with which saccharimetric measurements can be made.

For many years it has been the constant object of many scientific minds to increase the accuracy of saccharimetric measurements. The importance as a world industry of the production of sugar has increased from year to year. The magnitude of the material dealt in increases with time. It has thus become not only desirable, but necessary, because of the magnitude of the business transactions, to have the accuracy with which the tests on the commodity could be made, increased. In addition, the inevitable effects of competition have made necessary more and more accurate methods of analytical procedure in the process of

manufacture; and in the sugar research laboratories it is found in innumerable instances, that the border line of the unknown can only be pushed back by having available more precise methods of saccharimetric measurement.

It is now proposed, by reducing the normal weight to 20 grams, to take a step backward by decreasing the precision with which rotations can be measured. In justification of the proposed procedure, by which the accuracy of saccharimeter measurements would be reduced to but 77 per cent of their present value, it is stated that "the stock charge for most analytical operations is considerably less than 20 grams" and "the French normal weight is only 16.29 grams, and no objection has ever been brought against this standard on the ground of inadequacy of sample in the case of normal products."

LOSS IN PRECISION UNAVOIDABLE.

It is indeed difficult to comprehend how a situation could be brought into existence in which the proponents of a change which is bound to decrease the accuracy and ease with which rotations can be measured, should attempt to justify the change by the statements just quoted. Such arguments are obviously unscientific. So far as the writer knows there would be only one possibility of lessening the diminution in accuracy consequent upon a reduction in the normal weight. Since the magnitude of the half shadow angle of the polarizing system, that is the sensibility of the instrument, has its lower limit in the case of the saccharimeter in a great measure fixed by the average absorption of the raw sugar solution, and since the absorption is directly proportional to the number of absorbing ions in the solution, the question naturally arises of reducing the half shadow angle with a consequent gain in sensibility.

Could this be done, it would offset in a degree the loss in accuracy incidental to the reduction in the normal weight. A careful examination of this point unfortunately fails to show any adequate compensation for the loss in accuracy. The half shadow angle in any saccharimeter is also in a great measure dependent upon the optical homogeneity and accuracy of the cutting in respect to the optic axis, of the optical materials, such as calcite, quartz, etc., which the light traverses in its passage through the saccharimeter. Nevertheless in the case of each individual instrument a reduction in the normal weight should make possible a slight reduction in the half shadow angle. It is, however, a scientific fact that the slope of the curve showing the variation of the accuracy of reading as the half shadow angle is altered changes but slightly in the region of practicable half shadow angles.

Any practical gain in sensibility consequent upon a reduction in the half shadow angle which would be made possible by a lessening of the normal weight must therefore be ignored. We thus are brought face to face with the fact that any reduction in the magnitude of the present normal sugar weight is but a step backward so far as it affects the precision with which saccharimetric measurements can be made.

Under (C) we may consider as briefly as possible the effect on the international situation, so far as the future progress of the sugar industry is concerned, of any change in the normal sugar weight. For many years the best efforts of the best scientific brains in the world's sugar industry have been

largely directed to solving the problem of bringing about an international agreement on a normal sugar weight, and coincident with this, a unification of methods of analytical procedure. Great progress in bringing about this condition was made in 1900 by the International Sugar Commission sitting at Paris when it, for the first time, actually defined the basis of standardization of the 100-degree point of the saccharimeter; in doing which the present normal weight of 26 grams was adopted.

It seems hardly fair to stigmatize this weight by referring to it as the German normal weight. While it is true that the German scientific men agreed to its adoption, the act was committed by an international commission in a French city, and the old German Ventzke normal weight of 26.048 grams was discarded when the new weight was adopted. Subsequently the recommendations of the International Commission were adopted by practically the entire civilized world, with the exception of France.

UNIFICATION MOST IMPORTANT.

In other words, the sugar industry, for the first time in its history, came dangerously near to having a real international basis of comparison for all sugar measurements. The importance of attaining this condition overshadows in importance all other considerations in the selection of the fixed quantities which determine the basis of the saccharimeter standardization. The advantages of such unification in the commercial transactions of the industry are of the greatest importance; and without them the comparison of the work of the research men of the various nationalities is made only with the greatest difficulty.

Both the world at large and the French sugar industry have been joint losers by the fact that France has seen fit to retain her old normal weight of 16.29 grams. Science is greater than any nationality. It is the greatest single force extant that makes for civilization. In our efforts to bring about a uniform procedure throughout the sugar industry of the world, all so-called arguments of nationalism should be judged as unworthy of consideration. Only by such a procedure can the greatest good for the local industry in each individual country be accomplished. We may well pause to inquire what is to be the result should we throw over the agreement of the Paris International Commission of 1900.

WOULD SET UP THIRD STANDARD.

As has already been stated, there are in existence two recognized normal sugar weights, namely, 26 grams and 16.29 grams. In the event that America should change its normal weight to 20 grams, a value never officially adopted by any country, the world, in so far as it relates to sugar, would find itself divided into three camps, with the United States, Porto Rico, and the Hawaiian and Philippine Islands, and possibly Cuba, using 20 grams. England, all of Central Europe, Java, and probably South America, Canada, and Australia, as well as many lesser countries, would continue to use 26 grams. France and some of her colonies would use 16.29 grams. There is but one word to fittingly describe the resultant effects of such a situation on the comparative work of the sugar industry—chaos.

It has been suggested that France might discard her present normal weight

and adopt 20 grams, but there is nothing to indicate that such a condition of affairs would positively be brought about. With three values for the normal sugar weight in existence, each country or group of countries using a particular weight would determine and adopt its own values in absolute measurements of the rotations corresponding to that weight. Each country or group of countries would undoubtedly adopt values for all three sets of normal weights, but each set would differ for each normal from the other two sets. International comparison of tests or of research work based upon saccharimetric measurement would be inaccurate and difficult and, at best, always open to question.

The conditions existing in the sugar industry at the present time, which have been discussed above, direct our attention anew to the importance of America having a representative society of sugar chemists and technologists. Were such an organization in existence, all important questions of scientific and technical nature pertinent to the industry could receive the thorough and open discussion which their importance should merit. Certain it is, that official decision in all matters of this character should be left to such a representative body.

At the present time 26 grams is the official normal weight of the United States Government in the collection of the revenue on sugar, and in the standardization of all sugar-testing apparatus. In adopting its standards the government is actuated by the desire to adopt that which will be of greatest service to the industry; and is necessarily influenced in a large degree by what seems the best scientific practice as developed by the various countries which are deeply interested in the same subject. It is believed that the findings and recommendations of a representative society of sugar chemists and technologists would necessarily receive great consideration by the government in deciding what standards and specifications should be officially adopted for the greatest benefit of the sugar industry.

A CONSIDERATION OF SOME OBJECTIONS TO THE PROPOSED 20-GRAM SCALE.*

By DR. C. A. BROWNE and NOEL DEERR.

A recent canvass to determine the opinion of sugar chemists concerning the adoption of certain reforms in the manufacture of polariscopes, undertaken by independently acting committees and individuals, showed a very general belief that the present was a fitting time to discontinue the inconvenient French and German saccharimetric scales and to adopt instead the International scale, which is based upon a decimal normal sugar weight of 20 grams.

EXPRESSIONS FAVOR CHANGE.

As an indication of the sentiment upon this question the Hawaiian Sugar-

* Facts About Sugar, May 3, 1919.

Chemists' Association with a membership of about 100 voted almost unanimously for the proposed change. The Louisiana Chemists at a recent meeting, attended by about 40 of their number, passed a similar vote. The votes of those associations together with opinions expressed by individual chemists in various parts of the United States, Canada, Cuba, the West Indies and Great Britain, indicate a preponderance of opinion in favor of the 20 gram scale of over ten to one.

VIEWS OF DR. BATES.

In a recent criticism of the 20 gram scale by Dr. Frederick Bates, in *Facts About Sugar* for April 19, the statement was made that under the above procedure an unbiased expression of opinion could hardly be obtained; that chemists "have been presented with a sort of symposium, as it were, in favor of the 20 gram weight," and that if they were inclined to consider the objections to such a change they would practically be compelled to create their own arguments. This charge is hardly justified, for the symposium referred to contains opinions which are adverse as well as favorable. It is moreover a reflection upon the intelligence of chemists to say that they would unhesitatingly accede to a proposition without carefully considering all the pros and cons.

The canvass of opinion upon the normal weight question brought out a number of objections against making any change in standards, and as some of these objections were not advanced by Dr. Bates a general review of the leading arguments against the proposed change is herewith presented.

In order to prevent misunderstanding it will be necessary first of all to straighten out a tangle of nomenclature in which some of our friends upon the other side have become involved. An objection has been raised against calling the 26 gram scale German, or Ventzke, and the word "International" has been used as a substitute for these terms. The word "International" is used in this sense, for example, in Bureau of Standards, Circular 44, although this term had for many years previously been applied to the 20 gram scale, not only in such standard books as Sidersky's *Saccharimetrie et Polarimetrie* (Paris, 1908 edition, pages 100-103) but in the catalogs of instrument makers.

The terms German and Ventzke did not go out of use with the adoption of the 26 gram normal weight, as reference to the literature will show. In an official statement received before the war from the Physikalisch-Technische Reichsanstalt of Charlottenburg, the highest authority upon German standards of weight and measure, the term Ventzke is still applied to the 26 gram scale. We cannot see, therefore, why the accustomed designation of this scale should be considered as inaccurate or unfair.

TERM MISUSED IN TRADE.

The misuse of terms, which has resulted from calling the German, or Ventzke, scale "International" unfortunately has crept into the trade, for some 26 gram normal weight saccharimeters are now sold that bear the stamp "International Sugar Scale." Under present circumstances one can understand the desire of manufacturers to find a substitute for the distasteful word "German,"

but this is no excuse for adopting a term that has been attached for many years to another scale.

The reasons lately proposed in favor of the 20 gram scale were not recently prepared but are practically the same arguments as presented by Sidersky, Pellet, and Dupont before various sessions of the International Congress of Applied Chemistry.¹ The fact that Dupont's resolution to replace the French and German sugar scales by an international 20 gram standard was rejected by the International Commission upon Uniform Methods of Sugar Analysis at Berne, in 1906, is no argument against the validity of the proposed international scale. The vote at Berne was apparently not based upon any scientific objections to the 20 gram normal weight, but upon an unwillingness to disturb the then-existing order of things. It must also be remembered that the votes of the Berne meeting represented simply the views of the sugar chemists then present and that these attending members had received no mandate from absent chemists, who were interested in sugar to vote for them upon the question.

Such matters as this should obviously be decided only by a referendum in which absent chemists may have a vote. It was just such a referendum which Dupont² presented before the International Commission in 1903. Of the 47 replies received in response to a circular letter addressed to prominent chemists in 13 different countries, 18 accepted the 20 gram scale absolutely, 14 accepted it provisionally with the other scales, while 15 rejected it altogether. In 1906 at Rome a majority of Section V of the International Congress of Applied Chemistry also voted in favor of Dupont's resolution. Notwithstanding the unfavorable verdict at Berne, the 20 gram scale continued to make a strong appeal to chemists and instruments based upon this standard have been regularly sold.

CALCULATIONS SIMPLIFIED.

The advantages of the 20 gram standard in taking aliquots and multiples and in simplifying calculations are so well understood by practical chemists that it is needless to give detailed illustrations upon this point.

A well known sugar technologist writes from Cuba: "The proposed normal weight would greatly facilitate our control work. It would be especially convenient in the crystallizer and molasses control."

Probably more saccharimeters are used in food and general analytical laboratories than in the sugar industry, and in such establishments as these the 20 gram normal weight will be of particular benefit. A prominent food chemist in New York writes in this connection as follows: "As a result of many years practical experience in the analysis of honeys, sirups, preserves and other sugar-containing products, I know that a 20 gram normal weight will greatly simplify the work of analysis and calculation without any decrease in accuracy."

Many other opinions of a similar character could be quoted. The most earnest advocates of the 20 gram scale are in fact practical chemists and technologists, who appreciate the advantages of saving time and labor in calculation.

The argument that the specific rotation of sucrose at 20 grams in 100 cc. is about the maximum, which Dr. Bates criticizes, was we believe first proposed

by Dupont³ and no doubt relates to the correction for effect of concentration which is practically a straight line on the 20 gram scale; but a curve on the 26 gram scale. A straight line correction is naturally the most easy to remember and apply. While this correction is possibly not of much significance in practical work it might be of importance in certain problems of standardization and research.

The argument that diminishing the normal weight from 26 to 20 grams means a decrease of accuracy must be answered under the separate heads of sample and scale.

ACCURACY OF SAMPLE.

As regards accuracy of sample, it has previously been pointed out that the stock charge for the analysis of most commodities, such as fertilizers, cattle foods, coal, etc., is considerably less than 20 grams. The argument that more sample means greater accuracy has certainly not produced any increase in the ordinary commercial stock charge. For products of even character such as juices, sirups, and the great bulk of sugars, there would be no appreciable difference in polarization whether a 16.29 gram, a 20 gram, or a 26 gram charge were taken. With products of very uneven composition, as has been stated before, it is a simple matter to take multiples of the 20 gram weight, such as 50 grams in 250 cc., or 100 grams in 500 cc. Such multiple weights exist as one piece units in the analytical set and are therefore much more easy to manage than multiples of the 26 gram weight.

The argument that accuracy increases with the size of the sample has evidently a limit beyond which it is unnecessary and inconvenient to go. For some purposes of analysis the German scale requires a normal weight of certain sugars that is much too large. This is particularly true of sugars that are hard to dissolve, such as dextrose and lactose, which require a normal weight of over 32 grams. Chemists who work with these sugars often complain of the difficulty in handling such weights and prefer to make their assays upon smaller amounts. This trouble is largely overcome in case of the International scale which requires for dextrose and lactose a normal weight of about 25 grams.

ACCURACY OF READING.

As regards the 20 gram scale being less accurate to read on account of the divisions being crowded nearer together, this will depend upon conditions. In the design of a new instrument the distance between the scale divisions can, of course, be given any desired interval up to the maximum permitted by the available length of quartz and by the fixed half shadow angle of the polarizer, which on most saccharimeters varies between 5° and 9° . The average half shadow angle for many German saccharimeters, has been found to be about 8° which would give a range of sensibility between the points of maximum darkness in the two halves of the field of about 23 degrees on the Ventzke scale and of about 30° on the 20 gram International scale.

In order to have the same range of sensibility on the latter scale it will be necessary, therefore, to reduce the half shadow angle to 20-26 of its value or

from 8° to 6.1° . The latter angle gives a field which is a little darker at the end point than at 8° but it is not too small. Some of the new saccharimeters which are now being made have a fixed half shadow angle of only 5° and manufacturers can very well do this, for with the present concentrated filament lamps of high intensity a 5° half shadow angle would give a greater degree of accuracy in reading than 8° .

The splendid precision of French saccharimeters shows that the accuracy of a scale need not be affected by having a normal weight even as low as 16.29 grams. The French and German normal weights stand at what may be called the two permissible extremes. The International 20 gram weight is a convenient compromise between these limits and, affording a concentration about that of the average undiluted juice, is the more natural quantity to employ.

The matter of rescaling old 26 gram instruments to the proposed 20 gram standard is a subsidiary question and one which does not affect the main issue. We have seen short wedge 26 gram saccharimeters with metal scales which had the coarsely marked divisions so crowded that no shortening of the scale under such conditions would be advisable. On the other hand, if such an instrument were equipped with a fine marked ground glass scale, a higher degree of magnification might easily compensate for the shortening. The majority of metal scale saccharimeters would, we believe, permit of such rescaling with a greater accuracy and degree of comfort in reading. Unless the latter advantages were secured rescaling should of course not be attempted.

DETERMINATION OF PURITIES.

In the determination of purities some chemists dislike to dilute below 20° Brix and the objection has been made that a 20 gram scale would not have sufficient range for the polarization of high purity solutions of this concentration. While the majority of chemists probably dilute to nearer 15° than to 20° Brix and would, therefore, not experience this difficulty with the 20 gram scale, the above-mentioned objection can easily be overcome by extending the graduations of the new scale to $+115$, which will permit the polarization of 100 purity solutions of 21° Brix.

The defenders of the German scale have not considered in their discussion the inaccuracy of the present 26 gram standard, which, according to the measurements of Bates and Johnson⁴, gives a reading of only 99.895 for its normal weight of pure sucrose. In other words, not only are all saccharimeters of German and Austrian make in error to this extent, but all quartz plates, tables, and factors founded upon this scale are similarly wrong.

Much attention has been called by certain chemists to the periodic variations in the French normal weight, but they have lost sight of the fluctuations in the German standards. Rolfe⁵ and Sawyer⁶, in some measurements made in 1904 and 1905, found variations of as much as 0.35° Ventzke between the 100° point of different German saccharimeters, some of these being graduated apparently for 26.048 grams in 100 Mohr cc., and others for 26.048 grams in 100 true cc.

Inasmuch, therefore, as we have two or three kinds of German scales in existence and none of them correct, a reform of some kind is very evidently needed.

The advocates of the 20 gram scale hold that since the present scales, plates, tables, and factors need to be revised, the revision can be better accomplished upon the more convenient decimal 20 gram basis. In this connection we would quote the opinion of a well-known professor who has probably trained more chemists and technologists for the cane-sugar industry than any other man.

"I have gone over the question with considerable care and have convinced myself that all objections to the 20 gram standard are really trivial. The 20 gram normal will admit of easier calculations and of accuracy at least equal to the Ventzke. But my main reason for favoring it, frankly, is this: We really have no absolutely accurate standard, as things are at present, and if we change we might as well change to the most convenient standard. It would not do to have a modified German, or a modified French standard, not for any reasons of nationality but simply because to choose a standard along racial lines is a little bit ridiculous. If, however, we must practically get away from both standards in order to get the requisite accuracy, we might as well choose one which commends itself to our judgment. I believe that the time has come for us to do this."

CORRECTION OR A NEW SCALE?

It is held by some that a correction of the present 26 gram scale is all that is required and that this would be less disturbing. We understand in fact that certain makers of instruments intend to manufacture saccharimeters with just such a corrected scale. Let us suppose that these new 26 gram saccharimeters come into commercial comparison with the older 26 gram German instruments and with the newer German and Austrian instruments to be imported in the near future; what will be the result?

To quote the words of Dr. Bates, "There is but one word to fittingly describe the resultant effects of such a situation—chaos." Sugars will be bought and sold according to the German Reichsanstalt value of 100° sugar=34.657 angular degrees, or according to the United States Bureau of Standards value of 100° sugar=34.620 angular degrees, as individual interests may determine, and endless disputes will arise as to the accuracy and validity of tests.

The only relief from such an outcome is for the government, trades, and chemical societies of the non-Teutonic nations to adopt a standard in which the authorities of the German Reichsanstalt shall have no say. By doing this the sugar apparatus monopoly, which German and Austrian manufacturers have hitherto held, will be dealt an effective blow.

In the present period of readjustment it is well to put a final end to the ceaseless upholstering of the irrational French and German scales and to start out anew upon an international standard which shall be convenient as well as correct. Saccharimeters thus graduated will have their scale so far removed from that of French or German instruments that there will be no possibility of the confusion which is bound to arise between slightly differencing standards of the same scale. Certainly no one could dispute the merits of the 20 gram scale or hesitate as to its adoption, if the basic principles of saccharimetry were now being established for the first time.

The objection has been made that French and English manufacturers will not cooperate in such a movement and that it would be a mistake for America to attempt such a reform alone. To this we reply that French and English manufacturers are not only ready, but willing to cooperate in such a movement.

VIEWS OF FRENCH MANUFACTURERS.

One French instrument-maker writes: "Our saccharimeters are graduated according to a standard charge of 20 grams, which is very useful in practice and has been asked of us by our leading French chemists, especially the late Mr. Pellet." Another French manufacturer writes: "We approve without reserve the idea of replacing the French and German saccharimetric scales by an international scale whose normal weight shall be 20 grams. You may be assured that in scientific meetings devoted to physics and especially to chemistry we shall not hesitate to defend the value of this idea and to demonstrate its practical utility. We, therefore, congratulate you if you adopt now the saccharimetric scale for 20 grams, which will certainly be the future international weight."

A well-known English firm writes that they are also ready to supply instruments with the 20 gram scale, but state in this connection, "It is, however, most desirable that we should be able to check the accuracy of the new scale by every possible means, and we therefore write to ask if you could obtain for us a 100° point quartz control plate for this new scale, standardized and guaranteed by the Bureau of Standards."

It would of course be inadvisable for manufacturers in the United States and England to begin the manufacture of 20 gram saccharimeters without some definite international understanding as to the values of the proposed standard and the future of this movement to reform the sugar scale will depend upon the readiness of the United States Bureau of Standards and of similar establishments in Great Britain and France to give manufacturers such assistance as the English firm, above quoted, requests.

The old Wild Polaristrobometer, the pioneer of all decimal weight sugar scales, gave an angular rotation of 26.567° for a normal weight of 20 grams. The angular rotation of the latter weight according to Sidersky is 26.600° , and this is the value used by French manufacturers. The rotation calculated from the Reichsanstalt value of 26 grams is 26.664° . The rotation computed from the Bates-Jackson value of 26 grams is 26.636° . The rotation computed from the Landolt formula for the specific rotation of sucrose is 26.622° .

DIRECT DETERMINATION NEEDED.

The average of all these values is 26.62° which is probably very nearly correct, but what is needed is a direct determination of the angular rotation of the 100° point of the 20 gram scale under the same careful control of conditions as observed by Bates and Jackson in their investigations of the error in the present German scale and it is hoped that such a determination may soon be

made, not only by the United States Bureau of Standards, but by similar establishments in England and France.

A general desire upon the part of sugar chemists, food chemists, and manufacturers in different countries to cooperate in a movement which will place the science of saccharimetry upon a more simple rational basis has, we think, been amply demonstrated and with this presentation of the facts the friends of the 20 gram sugar scale must rest their case. The question now is, "Will the various governmental bureaus, who fix our standards, lend their support to such a movement?" The reform in our saccharimetric scale must be accomplished now or never. The desire of conservative chemists to cling to the old French or German scales should not prevent others from taking a forward step in the way of progress and simplification.

The great period of readjustment which came at the end of the eighteenth century witnessed two great reforms in standards—the decimal coinage and the metric system of weights and measures. The temporary inconvenience which the proposed change in our saccharimetric scale involves will be slight in comparison with that produced by these former innovations. Yet who would question now the wisdom of these earlier reforms?

[W. R. M.]

¹ Reports of the International Congress of Applied Chemistry, IV. (1900), pages 131-132; V. (1903), pages 129-135; VI. (1906), pages 563-569.

² Report of the International Congress of Applied Chemistry, V. (1903), page 131.

³ Report of the International Congress of Applied Chemistry, VI. (1906), page 565.

⁴ Scientific Paper No. 268 of the Bureau of Standards.

⁵ Mass. Institute of Technology Quarterly, Vol. XVIII., page 294.

⁶ Journal American Chemical Society, Vol. XXVI., page 990.

The Luce Cane Harvester.

We now learn that the Luce cane harvester has reached a development which has resulted in its being photographed in motion in some of its demonstrations in Cuba. The Luce Sugar Cane Harvester Co., Inc., has supplied us with a description of the moving-picture film, through which they are displaying the work of the harvesting machine, and have made a proposition to place a copy of this film with the Hawaiian interests.

The film is about 1400 feet long, requiring about twenty-eight minutes to run on the screen. The scenario is given as follows, and conveys an idea of the claims that are made for the Luce harvester:

1st scene:—The "harvesting" of sugar cane involves four distinct operations. The stalks are cut as close to the ground as possible: tops are cut off, leaves and trash removed, and stalks placed in piles ready for transportation to the mill. Wherever cane is grown these operations have been laboriously performed by hand labor, one stalk at a time, in this way * * *

2nd scene:—One of Mr. Luce's earlier experimental models (1914) shown now to give an idea of the developments and improvements made since then. Mr. Luce built his first experimental model in 1902.

3rd scene:—The result of seventeen years of constant experimentation and development. A 1919 model Luce sugar cane harvester capable of harvesting as much as from 150 to 200 tons in 10 hours.

4th scene:—Cutting a field row. Each field is cut in patches of about 18 to 20 rows. A Luce sugar cane harvester is here shown cutting the first or "field row" of one of these patches.

5th scene:—Here the "lane" made by cutting a field row has been widened. The harvester is turning the end of a patch preparatory to entering another row.

6th scene:—Harvester in operation. Each harvester requires a "crew" of three men and one boy. The man in front is watching for large stones and stumps and other obstructions. He also notes the condition of the separator plow between the rows. Any stalks too low to engage the pickup fingers are lifted into them. The man steering also keeps the bottom-cutters adjusted at the proper cutting level. Another "keeps an eye" on the machinery in general and operates the control levers when rounding the ends. The boy attends to dumping the hopper.

7th scene:—The two circular bottom-cutters which operate just at, or below, the ground, and, being power driven, sever the stalks with a clean draw cut. They are adjustable for height.

8th scene:—The upper wheel controls the adjustment of the bottom cutters. The lower wheel controls the motor-driven steering apparatus. The lower wheel is also in train with the rear steering wheel which is used when running the harvester backwards.

9th scene:—Severing the stalks at, or just below the level of the ground.

10th scene:—The bottom-cutting of a Luce sugar cane harvester leaves the "trash" and loose dirt on the stubble—a good condition for the growth of the next crop—and the point of severance is much lower than obtained by hand cutting. Here is shown part of a row of cane stools with the dirt and trash raked off. Also a near view of one of the stools showing the low square bottom-cutting.

11th scene:—A front view. The pickup chains are those farthest forward. The separator plow (at the left) is for dividing the rows in badly blown or tangled cane. The revolving topping knife below the topping fender or canopy is indicated by the pointing hand. The chains which carry the cane through the machine can be seen running rearwards and upwards from above the bottom cutters.

12th scene:—Topping. The tops strike against the fender or canopy and, on being cut, are thrown into the tops discharge chute at the left.

13th scene:—Tops are being discharged through the chute at the right. They are left on the ground. Topped and stripped cane is being discharged into the hopper.

14th scene:—Regardless of the length of cane stalks, the tops are cut off more or less at the proper point as is shown by these tops cut from stalks of various lengths.

15th scene:—Stripping brushes. These revolve very rapidly and brush the leaves and trash from the stalks as they are carried past the brushes by the conveyor chains.

16th scene:—The cane is dumped on the ground in piles ready for the mill. In Cuba, where these photographs were taken, the stalks are cut into two or more pieces in accordance with an ancient custom. This particular machine is equipped with an auxiliary cutter to do this work, which accounts for the short lengths of cane seen in the pile as compared with the standing cane.

17th scene:—A short piece of film showing Mr. Luce.

